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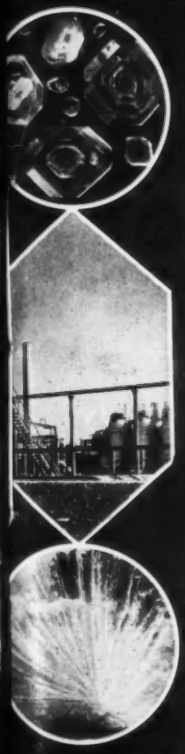

SHOW BOOK

ISSUE

MAY through AUGUST
1949

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The Better to Serve You

➤ IN RESPONSE to requests, CHEMISTRY here makes an innovation by combining its summer issues into this convenient handbook. It has rounded up the the recreational material with which chemists like to startle their friends. It is full of spectacular stunts you can use, whether for school room, for club meeting or for exhibits. You will want to keep it for future use.

For the coming year, CHEMISTRY is arranging other innovations. There will be special stress on laboratory directions for new materials, such as plastics. There will be reactions to show the presence of unusual elements, now becoming useful. There will be applications of new techniques, such as chromotography and ion exchange.

As always, CHEMISTRY during the coming year will bring you coverage of new developments in all related fields, from the nucleus of the atom to the farthest galaxy.

A series of articles is in preparation which will explain in simple language the actual data we get from the atom. These will show atomic phenomena, in terms not of abstract theory but of the evidence we see and measure, coming to us direct from the mysterious region where matter and electricity are one.

Practical articles on new products will appear from time to time, and recreational material will continue to enliven the magazine.

May we suggest that you renew your subscription to be sure to include the September issue, coming out early and specially geared to the necessities of the new school year?

CHEMISTRY

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THE CHEMISTRY SHOW BOOK

Edited by

Helen Miles Davis

Editor, CHEMISTRY Magazine

Science Service

WASHINGTON, D. C.

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Three Chemical Plays

These plays depend for their effect on the spectacular chemical demonstrations around which they are built. Heavy type refers the readers to the section after the end of each play where directions are given for producing these effects. For easier reference, each demonstration has also been given a name which appears in italics below its number in the text. It will be noted that in some instances the same reaction is used in different ways, and for different purposes.

No one should attempt to produce these demonstrations before an audience until he has become familiar with them under competent instruction. Chemists frequently have to handle dangerous materials, and it is important that they learn to do so with minimum risk of injury.

These plays are intended primarily for fun, with a sprinkling of chemical instruction thrown in for good measure. If any of the demonstrations are beyond your resources in materials or skill, by all means substitute another and rewrite the skit to suit. Chemistry is a science peculiarly rich in spectacular effects.

Chemical Magic

by Joseph H. Kraus

THE PERFORMANCE which always seems to get the greatest amount of applause is one in which comedy is mixed with more or less spectacular chemical effects. Each episode must be well rehearsed.

The key character is not the chemical Magician, but rather the Prince. He is the foil, whose antics create hilarity. The person for this part must be selected with the greatest care. If he is naturaly a wise-cracking student, so much the better. Although only two characters are esssential to the show, the addition of a good-looking girl will help.

The Cast

Magician

His costume should be plain but elegant. Evening dress, silk hat, stick and gloves, and a swirling cape, is one variant of it. Formal afternoon coat, striped trousers and a fancy waistcoat (the fancier the better) is another. Or a plain, dark suit with a startling flower in the buttonhole, or an electrically-lighted tie. There should always be some over-dramatic exaggeration about him, but he should contrast with the down-at-the-heels Prince.

Prince

Give him a fitting local name, as Prince Central, if that is the name of your school, or something to suggest the name of the organization giving the show. He is attired in shabby finery. His costume should correspond to and parody that of the Magician.

Mr. Kraus is a member of the staff of Science Service. This show is a composite of a number of amateur chemical magic shows he has given at intervals for a number of years in and around his home in New York City.

His trousers may be held up by a piece of stout cord. He wears white gloves and a high hat. He has a cane, which is a length of rubber hose with an umbrella handle stuck in one end. He wears a monocle-rim in one eye. There is a bright ribbon diagonally across his shirt-front, with a huge decoration (a novelty pin from the 5 and 10) in the center. There is a big brass chain across his vest, and a rip in the rear of his trousers, through which his shirt seems to stick out.

Girl

She is the Magician's assistant. She may be in evening dress, in a nurse's uniform, or in a startling fancy costume. Hers is a "straight" part. She assists in a perfectly matter-of-fact way, with no suggestion that either the silly antics of the Prince or the surprising tricks of the Magician are anything out of the ordinary in her life.

The Show

The curtain rises to disclose a table set with the apparatus necessary for the later experiments. There is a chair at each end of the table.

Behind the table stand the Magician and the Girl, who greet the audience with bows and smiles.

A knock on the door, or the ringing of a bell, calls the Girl off stage. The Magician unfolds a newspaper, sits down and starts to read.

Girl returns, and announces: Prince Central!

Magician nods to indicate that the Prince is to be ushered in.

There is a commotion at the door or side drop. The Prince is yelling: "Let me go! Unhand me!"

The audience sees that there is an arm around the Prince's neck, trying to drag him out of the room. He struggles. Finally he breaks in. It is his own arm which is wrapped around his neck.

The Prince immediately walks to the center of the stage, where the Girl awaits him.

In a gallant motion, the Prince removes his hat while he tries to lean on his cane. The cane is a length of rubber hose so it collapses under him and nearly precipitates him to the floor. Recovering his dignity, he hands his hat to the Girl, removes one glove, and starts to remove the second. This glove he pulls off by the yard. Yards and yards of glove he pulls off. He steps on the end, struggles, gets himself all wound up, and finally comes to the end. He rolls it up into a bundle and drops it and the first glove into the hat, but they fall right through.

As you have surmised, the hat has had its crown knocked out and just a tape hinge holds the flap. If the crown cannot be wedged in position, the Girl should see to it that the hat remains intact by holding a finger under the flap until the gloves are dropped into the hat. The glove for the left hand has been especially prepared by cutting the feet off a number of silk stockings and sewing them end to end. In this way a long tube is formed, which is easily concealed under the coat sleeve.

The prince, who is fastidious about his appearance, glances down and sees that his tattered shoes are dusty. Reaching for his kerchief, he pulls his coat aside to display the seat of

his patched trousers, with the "shirt" sticking through. As he reaches into his hind trousers pocket and pulls out his handkerchief, the "shirt tail" disappears.

(For this effect, two slits are cut through the cloth of the trousers and hind pocket. The handkerchief is threaded through the slits, with a goodly part left exposed. When the handkerchief is removed the "shirt" disappears.)

Flipping the dust off a chair with his handkerchief, the Prince puts one foot on the chair and polishes his shoe. He rubs and rubs, then removes his monocle and notices that the spot appears to be on the eyeglass. Using the same kerchief, he breathes on the glass and rubs it, back and front, then with two fingers. Finally, in exasperation, he pulls the kerchief clear through the frame. Of course, there is no glass there. Nevertheless, carefully adjusting the monocle, the Prince walks over, bows to the Magician, then lifts up the hand holding the newspaper and points to the headline.

Meanwhile the Girl has brought to front stage two clothes trees, and placed a lamp, with a reflector, so that it will shine toward the audience.

The Magician and the Prince remove the top sheet of the newspaper and thumbtack it across between the clothes trees, so that the sheet is spread to its full size. Picking up his wand, the Magician waves it in front of the paper. Smoke comes out of the end of the wand as he does so.

Demonstration No. 1

Magician's Wand

The Prince stands amazed. He touches a lighted cigarette to the end of the newspaper sheet. A charred trail of burned paper runs across from one end of the paper to the other, at the same time the action develops vertically. The Girl turns on the back light, and within a moment large burned areas have spelled out the word "Welcome" or any appropriate message, for the audience to read.

Demonstration No. 2

Burning Welcome

Meanwhile the Prince looks longingly at the wand. But he must not crab any part of the act by calling attention to himself while some other demonstration is taking place. Picking up the wand after the audience has had time to read the welcome, he sweeps it across the face of the paper, but nothing happens. As he lays the wand down he suddenly exclaims that he is on fire. Smoke is coming from his finger tips. The Girl methodically comes forward with the fire extinguisher and lets him have it, fingers and all.

Demonstration No. 3

Fire Extinguisher

Front stage, Magician and Girl start to arrange candles in two parallel rows on the table. The Prince motions that he would like to light them.

Putting his hand in his waistcoat, he removes one end of the dog chain and displays a huge lighter, which he flips and flips without result.

Returning it, he takes the chain-end out again, and a smaller lighter appears on it. Results are the same. Back it goes, to be brought out again with a midget lighter on the chain. Flipping the wheel of this one also produces no flame, so it also goes back, but this time a match appears at the end of the chain. This the

Prince proudly displays, and strikes.

The Prince's pockets are loaded with all sorts of things. None are attached to the end of the chain, but just held there whenever any one of them is needed. In addition to the lighters, there can be a salt shaker, a tooth pick, an alarm clock, or what you will.

Demonstration No. 4

Long-Burning Match

After striking the match, the Prince picks up one of the candles and lights it. He examines it, then pops it into his mouth, flame and all, chews it up and swallows it.

Demonstration No. 5

Edible Candles

He repeats this action with three or four of the candles, until the Magician pushes him aside. All this time he is holding on to the lighted match, entirely oblivious of the chance that the flame might be burning his fingers.

Meanwhile the Girl and the Magician have set out all the candles, in two rows. The Magician calls the Prince and asks him to light one candle at the end of the table. As soon as this lights, the flame leaps across an air gap of three inches or so and sets fire to the second candle, this to the third, and so forth.

When the front row candles are all burning, the Magician waves his magic wand across them, picks up a water pistol and shoots a stream of water on the candles. The front row goes out, the back row is lighted.

Demonstration No. 6

Self-Lighting Candles

The two end candles in the back row are taller than the others. The Magician picks up these two and one of the smaller ones from the row, and places the three of them, still burning, inside a large, straight-sided glass bowl. He lifts an apparently empty pitcher from the table and pours its invisible contents into the bowl containing the burning candles. One by one these go out, the shortest one first, the others in order of their height.

Demonstration No. 7

Invisible Liquid

After this, the Magician holds his hand over the candles still burning on the table. Each of these goes out in turn as he points to it, except the last three.

Demonstration No. 8

"Self-Extinguishing" Candles

The Girl removes the last three candles to another table in line with what appears to be a large bass drum set some 6 to 10 feet away.

Demonstration No. 9

Magic Drum

The Magician strikes the drum, and the candles are blown out. He aims it at the Prince and strikes it. The Prince staggers. Turning the face of the drum toward the audience, the Magician shows that there is a hole in it. He may demonstrate that there is quite a strong concussion wave issuing from the hole when the drum is struck.

The Girl now tidies up the demonstration table and removes the candles. Either those not needed further or the last one or two may be rolled into a piece of newspaper, which is then crushed into a small ball and thrown into the waste basket.

Demonstration No. 10

Disappearing Candles

The Girl now drops a cloth (which may seem to be the dust cloth she has used on the table) into the brass drum. The cloth has been saturated with titanium chloride. She must handle it with tongs. Striking the opposite side of the drum with a mallet makes huge smoke rings come out of the hole.

Demonstration No. 11

Smoke Rings

Sometimes it is possible to send one ring through another by striking softly for the first and then giving a sharp blow to make the second.

The Prince now comes forward with a huge candle. He lights the wick. He goes through the motions of extinguishing it with the pitcher, and by pointing his finger at it. Nothing happens. Considerably vexed, he blows it out, throws it on a tray or platter and pulls out the wick. The candle breaks into slices, which he may distribute to the audience to be eaten.

Demonstration No. 12

Shattered Candle

Two ring stands are set up on a large sheet of asbestos. A piece of iron wire about three feet long connects their tops. A folded sheet of newspaper with a target drawn on it is hung across the wire. The Magician stands beside a lighted candle at the opposite side of the stage and snaps at the flame with his fingers, declaring that he will try to hurl the flame at the target. Suddenly the paper sheet bursts into flame.

"Bull's eye!" exclaims the performer.

Demonstration No. 13

Throwing a Flame

"Think that's good?" asks the Prince, "Now watch this one!"

A small quantity of white powder is piled in the center of the asbestos sheet. This is wetted with the same solution used before. Everyone on stage moves away. A screen may be interposed between them and the sheet if desired. The Magician goes to his former position. He may light matches and pretend to toss them toward the sheet (putting them out as he does so), or he may make magic passes at it. Suddenly there is a terrific explosion, denoting, apparently, that the target has been reached.

Demonstration No. 14

Spontaneous Explosion

"How was that?" ask the Magician.

"Call that marksmanship?" derisively asks the Prince, "I'll give you a real example of marksmanship and won't make as many attempts to hit the target as you did."

Picking up a pistol and mirror, he whispers to the Girl. She at first shakes her head and appears fearful, finally becomes convinced when the Prince points to his row of medals. The Prince poses her with a disc about the size of a half-dollar held between her thumb and forefinger at arm's length. He rushes to the far side of the stage and aims his pistol.

Demonstration No. 15

Wonderful Marksmanship

At the first shot the disc flies to pieces. A handkerchief is tied around the eyes of the Prince. Another shot and another disc shatters. A cigarette is held in the Girl's lips. A shot and the tip is knocked off. Another and most of the rest of the cigarette falls.

The Prince declares that now he will attempt the most difficult of shots, a mirror shot, hitting two targets simultaneously with the same bullet. The Girl holds one of the targets between her teeth, the other in her hand directly in line with the one in her mouth.

The Prince juggles the mirror for some time to try to get the reflection right, then takes aim, not over his shoulder but directly at the mirror. The shot shatters the mirror and both targets!

Demonstrations for Chemical Magic

1. Magician's Wand

A glass tube has threaded through it several strands of soft twine, butcher's or valve-packing style. The twine is wetted with titanium chloride, which gives off copious white fumes. The tube is covered with black paper. An atomizer bulb of small size is fitted into the end.

When the Magician uses the wand, he presses the bulb, which is concealed in his palm. When the Prince uses it, he does not press the bulb until he is about to lay the wand down. Then he holds one hand over the open end and presses the bulb sharply several times. Enough titanium chloride will get on his fingers to cause them to smoke.

2. Burning Welcome

Two methods are available to scortch the word "Welcome" onto the paper for the audience to see. The letters, which should be similar to those shown in the cut, with no complete loops to fall out, may be painted onto the paper with the solution of yellow phosphorus in carbon disulfide described in Demonstration No. 13. For this purpose, since they do not have to catch fire spontaneously, the liquid should be diluted with 3 or 4 times its volume of carbon tetrachloride. This will retard the flame enough so that the paper will just scorch, and there will be less fire hazard.

In the other method, the message is painted on the paper with a water solution of potassium chlorate. After the water has evaporated, the trail of salt may be ignited with a cigarette. This method is used also to outline branching paths for the familiar "horse race" game, in which players choose the positions for their favorites at the beginning, then watch the devious courses pursued by the glowing lines across the paper, to see which reaches the opposite margin first.

3. Fire Extinguisher

It is important to have adequate fire extinguishers of the proper sorts ready at hand whenever any experiments involving any fire risk are performed. For this experiment, however, the "fire extinguisher" is an ordinary selzer bottle, wrapped in red paper. It is important to wash the titanium chloride off the hands immediately, and this the stream of water from the selzer bottle will do effectively. The Girl provides a towel as well, which she carries over her arm.

4. Long-Burning Match

The match actually is a short end of a common match attached to a wax taper, which runs up the Prince's

sleeve. As the taper burns it is gradually fed downward by gentle manipulation with the fingers. The Prince can do this without looking at it, while he keeps the attention of the audience on his candle-eating.

5. Edible Candles

Edible candles are made by pushing an apple corer or other metal tube down through a large peeled apple. Top and bottom of the apple cylinders are squared off with a knife. A sliver of Brazil nut meat (or of the meat of some other rich, oily nut) is pressed into the end to represent the wick. The nut, when lit by the match, burns with a yellowish flame.

The Prince blows out the flame at the same time that he pops the candle into his mouth. Care should be taken not to touch the tongue to the hot nut meat, but quick masceration of the apple will cool it off.

6. Self-Lighting Candles

The secret of the candle trick sequence is rather simple. The candles in the front row are connected by a thread which has been soaked in a concentrated solution of potassium nitrate and then dried. The thread acts as a fuse and leads the flame from candle to candle.

The candles in the back row are each topped with a tiny bit of metallic sodium. *Caution*: Apply with tongs. Do not handle metallic sodium with fingers. Be careful to set candles without dislodging sodium. Do not get it on clothing.

When the stream of water from the water pistol puts out the candles in the front row, it is guided to the wicks of the second row. Sodium in contact with water will ignite the wick.

7. Invisible Liquid

The pitcher which contains the invisible liquid actually is full of carbon dioxide. Perhaps the best way to keep it full is to drop some chips of dry ice into the pitcher and put a cover over it until ready for use.

8. "Self-Extinguishing" Candles

Dry ice is also responsible for extinguishing the candles by moving the fingers over them. Under the Magician's arm is a fountain syringe bag with a small tube running down inside his coat sleeve and attached to his wrist-watch strap. The bag contains some small lumps of dry ice. Pressure of the arm against the bag will force out the gas. Being heavier than air, it will drop down and snuff out the flame. *Caution*: Dry ice is much colder than frozen water. Protect yourself against its effects by using plenty of padding between its container and your skin.

9. Magic Drum

A large round hat-box (or an old bass drum) has a hole from 8 inches to a foot in diameter cut in one face. This need not be a drum head bladder. Cardboard is entirely satisfactory. The hole must be round, with smooth edges. You cannot blow square smoke rings.

The opposite face of the drum should be yielding. Cardboard is good here, or a rubber diaphragm cut from a large balloon and stretched on. If this face is struck a smart blow with a cloth-covered stick, vortex rings will issue from the opening. These may be seen if smoke (or titanium chloride vapor) is introduced into the drum.

A candle or other flame will be

snuffed out by the disturbance of the ring passing across it. A cardboard house may be knocked over at a distance of 20 or more feet if the drum is correctly aimed and given a sharp enough blow. Staggering the Prince with the force is just a bit of side play.

10. Disappearing Candles

Those candles which are to be crushed into a ball of paper actually are cylinders of stiff writing paper which was rolled around a candle and then slipped off. A small candle-end is fitted into the top of the cylinder. It should be just long enough to last through the performance. Naturally, when such a candle becomes the center of a roll of newspaper, you can crush the whole thing into a small, compact ball. The candles which are to be put into the glass bowl for Demonstration 6 and those to be saved for Demonstration 7 are real.

11. Smoke Rings

Titanium chloride is applied to a piece of cotton or cloth, which should be handled with a chemist's tongs, not with the fingers. It produces a large volume of "smoke," which the audience can see readily. The smoke rings from the drum are very fine.

12. Shattered Candle

As before (Demonstration 5), this candle is made of apple slices from several apples cut round with a cookie cutter. All are stacked up and threaded on a clean white string. The whole "candle" is rolled in powdered sugar and topped with a "wick" of Brazil nut. Pulling out the string allows the slices to fall apart. Tip slightly to one side as the string is pulled to get an orderly arrangement on the platter.

13. Throwing a Flame

Caution: This is a dangerous experiment. Care must be taken to see that none of the liquid drops on any surface likely to take fire. The asbestos sheet must be large enough to catch any flaming bits of newspaper. Fire extinguishers must be kept handy, though out of sight of the audience, and each person on the stage must be drilled in how to use them if necessary.

The solution with which the paper is saturated is made by dissolving yellow phosphorus about the size of two peas in 20 ml. of carbon disulfide. When the disulfide evaporates the phosphorus sets paper on fire spontaneously.

A large crock of a strong solution of copper nitrate in water should be available in the wings or under the table into which hands may be dipped and with which clothing may be saturated if a performer gets any of the phosphorus solution on himself. Spilling should not take place if ordinary precautions are taken.

Note: This experiment should be tested on the day and in the room in which the performance is to be given, to determine the approximate length of time it will take to evaporate the carbon disulfide. Under no circumstances should more of the solution be added to the paper after the first pouring. If the paper does not go off, ignite it with a long taper or match attached to a stick at least three feet long. A window pole is excellent.

14. Spontaneous Explosion

The white chemical is a level teaspoonful (*not more!*) of potassium chlorate. The solution is again the

white phosphorus dissolved in carbon disulfide.

Caution: This is a highly explosive reaction. No one must come near the asbestos sheet after the material has been moistened with the phosphorus solution, until the reaction is over. Phosphorus must never be handled with the fingers.

If the reaction does not take place within a suitable time, it should be kindled with a taper held at a distance of at least 3 feet. Use very small quantities only until you learn to manage the materials.

15. Wonderful Markmanship

The whole trick is a phoney. The pistol is a toy one. You may use one of the "safe" blank cartridge ones, but they are not available in some states. The noise of the shots may be simulated by the person working the public address system. Usually he produces a more realistic shot sound than you can do, simply by striking a leather pad with a stick, holding them close to the microphone.

The round targets are cheese crackers or something similar. These are pinched between the fingers at the proper time, to shatter them. In the case of the dual shot, the one between the teeth is bitten while the other is pinched.

The breakaway cigarette is arranged by cutting it through in one or two places with a sharp knife. The parts are held together by running a toothpick through the tobacco. The Girl grips the end of the toothpick between her teeth. She purses her lips at the shot. This draws the toothpick into her mouth and lets the end of the cigarette drop off.

The mirror is fitted loosely into its frame and held there with the fingers. At the shot it is allowed to fall. It breaks, of course, when it hits the floor.

Chem Quiz: What's the Dope?

➤ WEBSTER identifies dope with drugs, but also says something about some kinds of dope increasing efficiency. If you find your favorite stimulant here, you may comfort yourself with that. Anyway, see if you can identify the following formulas for chemicals with a definite effect on the human body. For instance, C_2H_5OH is ethyl alcohol. The rest are harder. Solutions of those you can't dope out are in the back of the book.

(1.) C_2H_5OH—its praises are widely sung, by some.
(2.) $C_{17}H_{19}NO_3 \cdot H_2O$—assuages pain.
(3.) $C_8H_{10}N_4O_2 \cdot H_2O$—is an eye-opener.
(4.) $C_{17}H_{21}NO_4$—benumbs the senses.
(5.) $C_2H_3O_2C_6H_9CO_2H$—is used for headaches.
(6.) $C_{17}H_{17}(C_2H_3O_2)_2NO_3$—is said to make one wild.
(7.) $C_{10}H_{15}NO$—is used for colds.
(8.) $C_9H_{13}NO_3$—we make this one ourselves.
(9.) $C_{10}H_{14}N_2$—is comforting to its users.
(10.) $C_9H_{13}N$—is a pep-er-up-er.
(11.) $CO(NHCO)_2C(C_2H_5)(C_6H_5)$—induces sleep.
(12.) $C_{18}H_{21}NO_3 \cdot H_2O$—helps the common cold.

School Days

by LLOYD FERGUSON

➤ "CHEMICAL MAGIC" experiments are quite an attraction to most audiences, and a play constructed around these experiments serves as an excellent setting for their demonstration. "School Days" is such a play, a one-act classroom scene, and is easy to carry out. The equipment required consists of a few common chemicals, some laboratory glassware, a blackboard, a table and some chairs. To minimize memory work, the players carry their own names.

Demonstration No. 16

Ticklish Explosive

After the audience has all been seated, someone scatters a little wet nitrogen triiodide around outdoors, outside the exit. This quickly dries and, of course, explodes when the audience walks out after leaving the play. The short tale at the end of the play is a build-up for this.

The Play

The curtain rises upon a classroom of chemistry students. Some are studying, others are setting up experiments on the table (which should be covered with an asbestos sheet). The teacher, Miss Richardson (comedy type), has not yet arrived. Braithwaite is preparing Demonstration 18 and Batiste Demonstration 19. Greene keeps looking at his watch while setting up the cigarette smoker, Demonstration 17. Botts is preparing the solution for soap bubbles for Demonstration 20, at the opposite side of the stage.

BRAITHWAITE: Say, Greene *(suddenly throws a big beaker to Greene, who catches it)*, what time is it?

GREENE: Ten-fifteen. *(Throws the beaker to Phillips, who may or may not catch it)* Here Phillips!

HOLMES: Miss Richardson is always late. I wonder where she spends her evenings.

PHILLIPS *(filling a beaker with water from a large bottle)*: With that new instructor, Mr. Flyright.

KENNEDY *(getting up to leave)*: We're wasting our time here. I'm going down to the cafeteria.

GREENE: Hungry already?

HOLMES: Lunch, or breakfast?

PHILLIPS: No, there's a new waitress down there, and is she cute!

(Kennedy sits down, looking discouraged).

PAXTON: Oh, let's give Miss Richardson five more minutes. If we leave now, she'll probably knock us out with another quiz tomorrow.

LOGAN *(busy writing, he looks up just as Greene gets his cigarette smoker going)*: Ha, Ha! That contraption of yours, Greene, would really go through a pack of cigarettes!

GREENE: Well, no smoking in the classrooms! I have to manage someway!

Dr. Ferguson is Associate Professor of Chemistry at Howard University. He wrote and produced this play with the assistance of Miss Juanita Boomer in 1945, at the Agricultural and Technical College, Greensboro, N. C. It has since been given also in Washington, D. C.

Demonstration No. 17

Cigarette Smoker

(Suddenly some cotton dampened with a little alcohol bursts into flame near Batiste and Braithwaite. They have had the opportunity to light it while the attention of the audience has been on the demonstration, but they seem to be surprised and alarmed.)

PHILLIPS *(rushing over with his beaker of water)*: Here, use this water to put it out!

(He sprinkles a little water on Braithwaite's powder, which sets off fireworks).

Demonstration No. 18

Purple Smoke

PHILLIPS: Whoops! Maybe that wasn't water!

HOLMES: Here! I know this is water!

(Holmes sprinkles water from his beaker on Batiste's powder, and more fireworks are released).

Demonstration No. 19

White Flame

PAXTON: No, no! Don't use water. You forgot it's bad to use water on fireworks. Here, use this sand. *(Brings sand).*

(Batiste does so, and fireworks go out.)

BOTTS *(displays his bowl of hydrogen and oxygen soap bubbles)*: Whee! Ain't I got fun!

Demonstration No. 20

Explosive Bubbles

(Barnes ignites bubbles with gas flame from long glass tube.)

HOLMES *(trying to study)*: Oh, cut it out! How can we study for this exam.?

LOGAN: You know, during exams there are two guys that burn me up.

BRAITHWAITE: Who are they?

LOGAN:

The first I'd really like to slam!
He always copies my exam.
The other is the dirty skunk
That covers his and lets me flunk!

(The class roars with laughter. The teacher enters. The class doesn't see her. She stamps her foot and shouts):

TEACHER: Here, here! Order! Order!

GREENE: Ice-cold orangeade.

BATISTE: I'll take a coke.

PHILLIPS: I'd like root beer.

BRAITHWAITE: Just make mine water. You see I'll be driving tonight.

(Class settles down. When all are seated, teacher stands beside table and picks up roll-book).

TEACHER: Now cease this foolishness. Please answer when I call your names. *(Each student answers "Here" as name is called).* Barnes - Batiste - Botts - Braithwaite - What kept you out of class yesterday, Mr. Braithwaite? Acute indigestion?

BRAITHWAITE: No, a cute Centralite.

TEACHER *(continuing roll call)*: Greene - Holmes - Kennedy - Mr. Kennedy, you missed my class yesterday, didn't you?

KENNEDY: Not at all! Not at all!

TEACHER *(continuing roll call)*: Logan - Paxton - Phillips - Terry - ump, absent. I hope all those present have prepared their lessons.

LOGAN: Oh, teacher, I have a poem.

TEACHER: All right, let's hear it.

LOGAN: A dansa, a data,
Perchansa out lata,
A classa, a quizza
No passa, gee whizza!

TEACHER: Was that your assignment? I should have asked all the morons in the class to stand up.

Paxton rises slowly.

TEACHER: What is it? Do you consider yourself a moron?

PAXTON: No, but I hate for you to be the only one standing.

(Class laughs. Miss Terry strolls in.)

TEACHER: Miss Terry, you are twenty minutes late. You should have been here at ten o'clock.

MISS TERRY: Why? What happened?

TEACHER *(severely)*: Never mind! Are you ready with the experiment I assigned you last week?

MISS TERRY: Goodness, I - er - well, I'll let you see what I've done. *(Begins preparations for Demonstration No. 24.)*

TEACHER: Somebody asked for an orangeade. While Miss Terry gets her experiment ready, I'll show you how independent a chemist can be. When I want an orangeade I can pour myself one from plain water, like this:—

Demonstration No. 21

Orangeade from Water

— and when I see you pupils coming I can turn it back into water by adding more water!

PHILLIPS: Let's see you drink it!

TEACHER: Let's see you do the experiment!

PHILLIPS: OK. Now here I have some plain water. From the same pitcher I'll pour some — *(looks surprised)* — ink!

Demonstration No. 22

Disappearing Ink

— and when I am through writing, I can recover my pure water. *(Shows by pantomime that he wasn't sure it would work, and is relieved to find that it does.)*

HOLMES: I can beat that! I can pour red wine, blueing, black ink and tea all from the same pitcher.

Demonstration No. 23

Magic Pitcher

TEACHER: Suppose you show us.

(After the demonstration, the teacher calls on Miss Terry, who has been preparing the volcano experiment. If stage equipment permits it, this may be made into a fairly elaborate miniature scene, and the stage darkened while it is shown. If not, it may be set off in a shaded place with a dark background.)

TEACHER: Is your experiment ready now, Miss Terry?

MISS TERRY: Yes, my problem was to construct a miniature volcano. *(She may add a little talk about volcanoes, if that is desired.)*

Demonstration No. 24

Volcano

TEACHER: That was very good. Now as preparation for tomorrow's lesson, I will show you how to make a twisting, gruesome snake from a simple white powder.

Demonstration No. 25

Gruesome Snake

GREENE: Well, can you beat that!

PAXTON: Astounding!

KENNEDY: Colossal!

LOGAN: Stupendous!

BATISTE: Say, will you do that again?

(Teacher lights the rest of the pellets.)

(As the "snakes" die down, Barnes is seen to be busy writing. Paxton and Kennedy are arguing, their voices beginning in whispers but growing increasingly louder.)

GREENE: That's quite handy to know, ahem!

TEACHER: Here, here, what's all this about, you two? Stop that argument.

PAXTON: Mr. Kennedy claims I can't see a fish that is in the water.

KENNEDY: That's right, Miss Richardson, let me prove it. (He goes to the blackboard and draws a diagram of the bending of light rays when passing from one medium to another.)

KENNEDY: You know that water bends the rays of light. Hence, when you are looking at a fish in water, he appears to be in a different spot than he really is. Now you can't see an object where it is not. Therefore you can't see a fish in water.

PAXTON: All right, Mr. Smarty, I'll bet you that *one* cat has *three* tails.

KENNEDY: I know that isn't true.

PAXTON: *(going to the blackboard)*: No cat has two tails, right? *(Writes down the figure 2.)*

KENNEDY: Right!

PAXTON: And one cat has one more tail than no cats, correct? (Writes the numeral 1 below the 2 for addition.)

KENNEDY: Correct!

PAXTON: Therefore, *(adding 1 and 2)* one cat has three tails. *(Class laughs.)*

TEACHER: Mr. Barnes, just what are you writing over there?

BARNES: Who, me? Er-Oh! I'm just writing to my Aunt Susie.

(Class laughs derisively. Calls of "Oh, yeah!" and "Aunt Susie, my eye!" etc.)

TEACHER: Suppose you let us hear just what you are writing to your *dear* "Aunt Susie!"

(Barnes crumples one piece of paper and drops it on the floor. Seizing the rest of the paper, he rises and gives a three to five minute talk on some phase of chemistry. This may well be the purpose of the whole show — a discussion of the usefulness of chemistry in daily life, or an argument on why more students should enroll in the chemistry course, etc.).

TEACHER: Well, Mr. Barnes! Although that isn't what you were writing, for I saw you drop your note on the floor, that was interesting and informative. I'm very impressed. Thank you. But I must give you a little warning about chemistry.

'Way back in 1946, just after World War II, when butter was very scarce, a certain chemistry teacher here at Central decided to make his own butter out of chemicals. After going through several very complicated reactions, he succeeded in making himself five pounds of very good-looking butter. But then, while leaving this very building with his butter, he accidentally dropped it — and that butter exploded into many, many particles. And do you know that, even

yet, every time you leave this building and step on any of those particles, they explode?

Now let's see, Mr. Braithwaite, you will remain after the class is dismissed.

BRAITHWAITE: But, Miss Richardson, that wasn't me that was so sassy. That was Miss Terry.

TEACHER: Now, Mr. Braithwaite, it wouldn't be any fun for me if I kept Miss Terry after school!

(Class whistles, starts leaving.)

TEACHER: Class dismissed.

(Curtain).

Demonstrations for School Days

16. Ticklish Explosive

This is nitrogen triiodide, prepared by putting a few iodine crystals or a little powdered iodine into a test tube and covering with an excess of concentrated ammonium hydroxide. A dark brownish precipitate will form, which must be kept wet. When ready for use, filter and handle on wet filter paper.

(Caution: Use the smallest quantities, only as much as is picked up on the end of a toothpick. Never leave any of the dry compound around. This is said to be one of the most sensitive explosives known. An insect walking over the crystals will explode them. This property may be demonstrated by tickling them with a feather — held at arm's length, of course!

17. Cigarette Smoker

A large bottle is fitted with a two-hole stopper. Through one hole is passed a long glass tube bent to form a siphon. Through the other hole, a short glass tube, large enough to hold a cigarette. This tube is bent horizontally (or, if you wish to demonstrate the tarry liquid in the smoke, it can be trapped by putting a V-bend between the cigarette and the stopper). When the siphon is started, air is drawn through the lighted cigarette and the bottle becomes filled with white smoke.

18. Purple Smoke

Equal portions of zinc dust and powdered iodine are mixed and spread out in 1"-diameter spots. When water is sprinkled on these spots, clouds of iodine vapor are given off. *This must be done on an adequate sheet of asbestos.*

19. White Flame

Eight parts of ammonium nitrate and one part of ammonium chloride, by weight, are powdered *separately*, then mixed. The mixture is spread out in half-dollar size spots and each spot is covered with zinc dust. When water is sprinkled on these spots a violent reaction takes place, accompanied by bluish-white flames and white fumes. *On a sheet of asbestos, as above.*

20. Explosive Bubbles

Hydrogen plus oxygen soap bubbles are blown with a clay pipe or a thistle tube, using tanks of hydrogen and oxygen and mixing them by passing them through a thistle tube. Make a concentrated soap solution and add glycerine to make the bubbles last longer.

(Caution: A mixture of hydrogen and oxygen in the ratio of 2 to 1 is

highly explosive. Do not release hydrogen while any flame is burning on the stage. After blowing bubbles, disconnect the bubble tube and place the bowl with bubbles on the asbestos-covered table, away from tanks of hydrogen and oxygen gases. Ignite bubbles carefully by means of a small gas flame burning at the end of a long glass tube. They will burn with a flash if there is more hydrogen than oxygen, or explode with a loud report if the mixture is about 2 to 1. The desired effect can be obtained by trial and error.

21. Orangeade from Water

One 600 ml. beaker is $\frac{1}{3}$ filled with a dilute solution of mercuric chloride *(Caution: deadly poison!)* and a second 600 ml. beaker is $\frac{1}{2}$ filled with a solution of potassium iodide. When part of the latter solution is poured into the mercuric chloride solution, a salmon-orange color appears *("orangeade")* but upon adding all of the potassium iodide solution the color suddenly disappears ("water"). *Note: nobody drinks any of these solutions!*

22. Disappearing Ink

Before performing this trick in the presence of the audience, five 400 ml. beakers are prepared as follows:— In beaker no. 1 is placed 0.5 ml. of a ten per cent ferric chloride solution; in beaker no. 3 is placed 0.5 ml. of a five per cent aqueous tannic acid solution; in beaker no. 5 is placed 1 ml. of concentrated sulfuric acid. Nothing is put into beakers nos. 2 and 4.

When showing the trick to the audience, the performer pours each of the beakers about $\frac{2}{3}$ full of water from an opaque pitcher or a large dark bottle, remarking that he has poured out pure water. Then, seeming to be confused, he pours the contents of beakers 1, 2 and 3 back into the pitcher. After shaking, he pours ink *(actually)* out. When he says he is through writing he pours the contents of all the beakers back into the pitcher. The liquid he now pours out of it is colorless.

23. Magic Pitcher

As in Demonstration No. 22, four 400 ml. beakers are prepared before they are shown to the audience. In this case, such a small amount of liquid is put into each one that they appear empty from a distance, and may even be brought in upside down, to heighten that effect. In beaker No. 1 is placed 0.5 ml. of 1 N potassium thiocyanate; in beaker No. 2 is placed 0.5 ml. of very dilute potassium ferrocyanide; in beaker No. 3 is placed 0.5 ml. of five per cent aqueous tannic acid solution; beaker No. 4 is left empty. The performer pours a weak ferric chloride solution from a pitcher into each of the beakers, obtaining from No. 1 a "red wine," from No. 2 "blueing," from No. 3 "black ink" and from No. 4 "cold tea."

24. Volcano

A large porcelain crucible is filled with powdered ammonium dichromate, and the powder ignited. Sparks rise for a long time and a huge amount of greenish-black ash is produced. This is most effective if the crucible is surrounded by sand to make it appear like a mountain peak, and the experiment done in the dark.

25. Gruesome Snake

Pellets of mercuric thiocyanate,

about the size of a half-dollar and ¾ in. to 1 in. high, are shaped from the mushy precipitate which is obtained by mixing solutions of mercuric chloride *(Caution: deadly poison!)* and potassium thiocyanate. These are prepared ahead of time, and dried by standing at room temperature. When ignited, a voluminous, coiling, yellow-green ash is formed.

Chem Quiz: It's the Law!

➤ SOMEBODY'S LAW needs to be invoked in each of the following cases. Can you tell whose? and state the Law? and give some facts about the author of it? If not, you are sentenced to banishment to answer pages.

1. You have a liter of gas at room temperature which you want to heat to 100° C., keeping the pressure the same. Whose law will you use to find how big a container you will need?

2. You want to know the volume of a certain gas at 20°C. Whose law will you use to find it for sea-level and for the top of a mountain a mile high?

3. You want to combine a liter of hydrogen with a volume of chlorine gas to form HCl. Whose law will tell you how much chlorine you should use?

4. Into a given container filled with air you want to introduce an equal volume of carbon dioxide. Whose law will tell you what effect the new gas will have on the pressure in the container?

5. You are running two electroplating baths, using the same current but twice as concentrated a solution for one as for the other. Whose law will tell you what the difference will be in the amount of metal deposited?

6. You are measuring the diffusion rates of two gases. The density of one gas is twice that of the other. Whose law will tell you which will diffuse faster, and by how much?

7. You are studying the effect that non-ionizing compounds have on the freezing and boiling points of water when they are dissolved in it. Whose law will give you the rule by which this effect can be calculated for different compounds?

8. You are about to start a reaction from which it is possible to get either of two different products, under different conditions. By whose law can you calculate the proper conditions for the product you want?

9. If you keep the temperature and pressure constant, what other factor in a chemical solution can you vary? The formula you will use to make calculations for the results as you vary these factors is written:

$$F = C + 2 - P$$

If C stands for the number of components of a system in chemical equilibrium and P stands for the number of mechanically separable and physically distinct portions of the system, such as gases, solutions or crystalline states, what does F stand for? Who discovered this relationship?

If you have had a year of chemistry, you ought to know three of these laws. An upper classman specializing in chemistry might be expected to know six. If you are a chemical engineer in charge of operations, you may have to use them all. But cheer up! We learned a lot by looking them up in handbooks and encyclopedias, too.

All Wet

A Scientific (?) Treatise on Water

by Louis C. Jordy

➤ A LECTURE DEMONSTRATION by Prof. Phineas T. Vacuum, D. Ph., assisted by his famous German colleague, Herr T. U. Tonik, of the University of Pinaud.

The Cast

Professor Vacuum: Wears old dress suit with gay striped shirt and large, flowing Windsor tie; soft hat; overcoat with manuscript in inside pocket; wears pince-nez glasses with broad black ribbon; speaks with exaggerated English accent (Water is "Woe-tah").

Herr Tonik: Comedy German type; dress suit with gay four-in-hand tie; stove-pipe hat; heavy rimmed glasses; smokes a big pipe.

Properties: Two or more large books; plain table and two chairs; asbestos sheet to protect table top; two half-pint pocket flasks of clear glass; four clear glass pitchers, capacity about 500 ml. each; one opaque pitcher, capacity at least 1000 ml.; eight or ten plain glass tumblers, capacity 200-250 ml. each; bottle labelled " Hard Water," capacity 200 ml.; one beaker for "solid alcohol," capacity 200 ml.; small anvil and hammer; two towels; two basins; commercial cylinders of hydrogen and oxygen for explosive soap bubbles.

This play is reprinted from Chemistry Leaflet, Vol. VI., No. 2, Sept. 22, 1932. It was first presented at the annual luncheon of the Science Teachers' Association of New York City, in 1932. It was first published in the *Hexagon* of Alpha Chi Sigma.

The Show

The curtain rises to disclose the stage empty except for chairs and the table holding apparatus for the demonstrations. After a stage wait of about half a minute the curtain is lowered for another stage wait, and finaly rises again to disclose the stage still empty. After an interval, Prof. Vacuum, still wearing an overcoat and hat and carrying an armful of books, dashes in, L.

Prof. V.: I'm *so* sorry!

(He trips and falls heavily, spilling books in all directions. Picks himself up and begins talking breathlessly while still removing hat and coat, which he places on a chair, R.)

. . . Ladies and gentlemen: I'm *so* sorry!

(Stops suddenly and feels cautiously about hip pocket, carefully extracting a clear glass half-pint flask containing colored water and a little phosphine gas. Breathes a sigh of relief at finding flask intact and places it on table.)

Demonstration No. 26

Prof. Vacuum's Flask

Ah - - - I find it necessary to take a little stimulant at times - - - ah - - - Really I must apologize to you for being so late and for appearing before you so unceremoniously, but the fact is, I have been so absorbed recently in an important investigation that I had completely forgotten this engagement. It is a *most* fascinating bit of

research. *(Slowly and impressively)* I am just on the verge of perfecting a synthetic material which will make a perfect substitute for the seeds in raspberry jam. So absorbing has this problem been that I confess I have not prepared as carefully as I should for this evening's program, and I must ask you to pardon me if I refer rather frequently to my - - - ah - - - notes. Frankly, I should not have considered appearing before you at all if it had not been for the invaluable assistance of my colleague, Herr Tonik, whom I wish to introduce at this time - - -

(Looks about in puzzled fashion and finally calls into wings) Herr Tonik! Herr Tonik! Wo sind Sie?

(Enter Herr T., still wearing his stove-pipe hat. Prof. V. nudges him and points guardedly to the hat, but Herr T. only looks vacantly up at the ceiling.)

PROF. V.: Der Hut! *(Stamps his foot)* Der Hut!, Mann!

HERR T. *(angrily)*: Hoot mon! Do I look like a Scotchman?

(Prof. V. snatches off hat and hands it to Herr T., then turns and comes downstage to go on with his introduction. As soon as his back is turned, Herr T. promptly replaces hat on his head. Prof. V. continues):

PROF. V. It is indeed a pleasure, ladies and gentlemen, to have present this evening a scientist so distinguished in both the related fields of chemistry and biology; and I am particularly gratified at being able to announce at this time the completion of his latest and greatest piece of work —He tells me that he has finally succeeded in crossing the ordinary honey-bee with the woodpecker, thereby obtaining a hybrid which is able to tap the sugar-maple trees, extract the sap, and convert it directly into delicious maple syrup. You will see that this discovery is bound to revolutionize the entire maple syrup industry - - - Ladies and gentlemen, it is my privilege to introduce to you the renowned Herr Tonik, of the University of Pinaud - - -

(He turns, to find that Herr T. has disappeared. While Prof. V. has been speaking, Herr T. has spied the flask on the table and sidled over to inspect it. He takes from his pocket a similar flask which is, however, nearly empty. He compares the volumes of liquid in the two flasks, sets his own down on the table and proceeds to inspect Prof. V's; finally uncorks it, whereat the phosphine flames up spontaneously. Herr T. hastily decamps, holding the flask at arm's length, just as Prof. V. approaches the climax of his introduction).

Demonstration No. 27

Herr Tonik's Flask

PROF. V.: Herr Tonik! Where is that man?

(Goes to wings and drags in Herr T., again taking off the stove-pipe hat, which is replaced by Herr T. as soon as returned)

- - - This, ladies and gentlemen, is my renowned associate, Herr Tonik.

(Herr T. has picked up one of the books from the floor, pushed Prof. V's overcoat off the chair, and seated himself. He buries himself in the book, ignoring both audience and Prof. V. He continues to be oblivious of everything throughout the lecture, except when appealed to directly.)

PROF. V.: Now, as I was saying, I feel but poorly prepared to address you this evening, but the experiments may interest you, and the fact that they have all been prepared and tested by Herr Tonik is itself a guarantee of their success - - - Now, the subject of my lecture this evening is - - - ah - - -

(Feels in one coat pocket and then in another, gets increasingly nervous and feels desperately in all his pockets in turn. Finally has an inspiration, turns to his overcoat—which has been thrown on the floor—and finds notes in an inside pocket. Gets out pince-nez glasses, which he continues to remove and replace throughout the lecture as required.)

- - - Ah, yes! My topic for this evening is WATER — possibly a rather deep subject at times, though not necessarily a dry one. I shall try to make it clear, but under the circumstances already mentioned, you will pardon me if at times I may appear - - - ah - - - all at sea.

Demonstration No. 28

Water, I

Now, as you all know, water is a tasteless, odorless, colorless liquid—

(Picks up clear glass pitcher and tumbler and pours glass half full. The water in the tumbler turns deep blue, while that in the pitcher is still colorless. Prof. V. is puzzled.)

Excuse me! I must consult my notes - - -

(Looks at notes, then at solution again, and finally appeals to Herr T.)

Herr Tonik! Was ist hier los?

HERR T. *(testily)*: Ach! Pour it oud!

PROF. V.: Pour it out?

(He pours the glass full, whereupon the liquid becomes colorless again. He looks at it, then at the notes, then at Herr T., who is deep in his book again, and finally says:)

Well, if you don't mind, I think we shall proceed to the next experiment.

Demonstration No. 29

Water, II

PROF. V.: Now, as I was saying, water is a tasteless, odorless, colorless liquid - - -

(Picks up clean glass pitcher and tumbler and mixes solutions for clock reaction, timed to produce a deep blue color suddenly at the end of one minute. Assures himself that the mixture is colorless, and then proceeds:)

- - - a colorless liquid which has always existed rather abundantly on the earth. It is sometimes known as "Adam's Ale," because, I understand, the absence of all other beverages from the Garden of Eden is supposed to have been what *ailed* Adam. It has occasionally been used for drinking purposes in the past - - - when nothing else was to be had; but I understand that it is chiefly used to - - - ah - - - push under bridges. My colleague, Herr Tonik, assures me that in the "Zeitschrift für reine und angewandte Wissenschaft" he has found a reference stating that water is sometimes employed for bathing purposes - - - by bathing beauties - - - when they cannot get champagne.

Well, as I was saying, water is a tasteless, colorless, odorless substance—

(at this point the liquid in the glass suddenly turns deep blue)

- - - Excuse me! I really must consult my notes - - -

(Looks at notes, then again at liquid, then at Herr T., and finally at liquid again)

- - - ah - - - shall we proceed to another experiment? As I have already stated - - -

Demonstration No. 30

Water, III

(picks up clear glass pitcher and tumbler and mixes solution.)

PROF. V.: Water is a tasteless, odorless, colorless liquid which is found extensively in a great many familiar things, such as railroad stocks, high-test gasoline, and the like. It is present in cabbages to the extent of 95 per cent., the remaining 5 per cent. being mostly - - - ah - - - smell. Fresh milk contains 87 per cent. of water - - -

(looks at liquid in tumbler; it has now turned milky)

- - - or is it that fresh water contains 87 per cent of milk? - - - If you don't mind, I *must* consult my notes -

(Looks at notes, then at Herr T., then at the liquid)

- - - No, my notes say distinctly that milk is 87 per cent water! This is not at all clear - - - ah - - - suppose we try another experiment.

Demonstration No. 31

Water, IV

(Picks up clear glass pitcher and tumbler and pours glass half full. The water in the tumbler turns bright pink, while that in the pitcher is still colorless. Prof. V. looks first at one, then the other, fumbles notes, and finally appeals timidly to Herr T.)

PROF. V.: Herr Tonik! Das geht nicht! Was ist los?

HERR T. *(angrily)*: Pour it oud! Pour it oud!

PROF. V.: Pour it out?

(He pours the glass full, and the contents are colorless again. He looks at the notes, glares at Herr T., and finally says):

- - - Oh, well, we have *other* experiments. Now, as I have remarked - - -

(Picks up opaque pitcher and fills four tumblers)

- - - water is a colorless liquid - - -

Demonstration No.32

Water, V

(He is suddenly attacked by a coughing spell, picks up the first tumbler and drinks half the contents, then absent-mindedly pours the remainder, along with the contents of the second and third glases, back into the pitcher)

- - - ah - - - Let me see — Where was I? - - - *(Looks at notes)* - - - Oh, yes! Pure water is a colorless substance - - -

(Refills two tumblers; the liquid is now black. Makes an exclamation of digust and empties all the tumblers back into the pitcher; fumbles helplessly at notes and appeals again to Herr T.)

PROF. V.: Herr Tonik! Was tun wir zunächst?

(Herr T. slams book furiously and comes to the rescue)

HERR T.: Ach! Welche Dummheit! POUR IT OUD!

PROF. V.: Ah, yes, of course!

(He fills the three glasses again;

the liquid is colorless; he is triumphant).

PROF. V.: You see, ladies and gentlemen! I was right — water is really a colorless substance. And now let us proceed to another experiment. Water, as I have conclusively demonstrated, is a colorless liquid which does not assume the solid form until cooled to 32 degrees Fahrenheit.

Demonstration No. 33

"Hard Water"

(He mixes liquids, the mass "freezes" immediately)

PROF. V.: Why, what is this? I must consult my notes!

(Does so; then examines label on bottle; sighs with relief)

- - - Ah, yes! My notes say that this was a specimen of unusually *hard* water. I shall now break some of the ice in pieces on this anvil.

Demonstration No. 34

Inflammable Ice

(Digs some of the "ice" out of the beaker with a knife, selects a piece and puts it on anvil in contact with CrO_3. The lump bursts into flame which also involves his fingers. He shakes his hand and blows on it vigorously, being careful, however, not to extinguish the burning lump of "ice")

PROF. V.: Oh, I say — that doesn't happen, you know — really it doesn't! I think we should proceed with another experiment - - - but first, if you will permit me, I shall wash my hands.

Demonstration No. 35

For Washing Hands

(Herr T. comes forward and holds towel impregnated with KCNS. Prof. V. rinses hands in basin containing some ferric solution, talking as he does so.)

PROF. V.: You will notice that I use no soap - - - It is a mistake to think that soap is needed for cleansing purposes. I use none, and as you see - - -

(By this time he has wiped hands on towel, coloring both towel and hands bright red. He glares at Herr T. and says with great dignity:)

PROF. V.: Herr Tonik, you will please bring some more water - - - and you might add a little - - - ah - - - soap.

Demonstration No. 36

Explosive Soap Bubbles

(Herr T. pours some soap solution into another basin provided with a device for blowing up a lather of bubbles of "detonating gas." When Prof. V. has collected a good handful of explosive lather, Herr T. offers another towel, which is indignantly refused, Prof. V saying:)

PROF. V.: No thank you! I shall dry my hands over this flame.

(Prof. V. shakes his hands over flame of the still burning solid alcohol, and the gases explode with a loud report. Prof. V. staggers back, his hand to his heart, then reaches for his flask of "stimulant." He notices that the flask is nearly empty, looks suspiciously at Herr T., and shakes the flask, whereupon the contents immediately turn colorless. He seizes hammer and says decisively:)

PROF. V.: Ladies and gentlemen, I think we shall dispense with any

further experiments this evening - - - I feel the need of holding a very important conference with my colleague - - - At once!

(Exits in hot pursuit of Herr T. Curtain.)

Demonstrations for All Wet

26. **Prof. Vacuum's Flask**

A half-pint flask of clear glass should be filled with water colored brown by a little caramel. A few bubbles of phosphine are added by replacement of water. Stopper should be of rubber and fit tightly. Phosphine is best generated by reaction of calcium phosphide and water. When the flask is uncorked, later, by Herr Tonik, the phosphine takes fire spontaneously and flames up.

As an alternative to the use of phosphine, Prof. Vacuum's flask may contain dilute acid. Then, when Herr Tonik first examines it he drops in a large tablet of sodium bicarbonate and recorks the flask. This will blow out the stopper in a few seconds.

27. **Herr Tonik's Flask**

Herr Tonik's flask looks just like Prof. Vacuum's, but is, instead, about one-fourth filled with a solution of iodine in potassium iodide, of about the same color as the caramel solution in Prof. V's. It has a cork stopper with a hole dug out of the inner end, into which a good-sized crystal of sodium thiosulfate is wedged.

It is well not to put this stopper into position until just before the lecture, as the "hypo' is somewhat hygroscopic under these conditions. Care must be taken not to shake the flask prematurely, as a single shake will usually discharge the color of the iodine immediately.

28. **Water, I.**

The tumbler contains a single drop of concentrated solution of iodine in KI or NaI. The pitcher contains a freshly prepared starch solution to which has been added a little sodium thiosulfate (hypo). The concentration should be so adjusted that between 100 and 200 ml. of the hypo solution are required for one drop of iodine solution.

29. **Water, II.**

This is the famous "clock reaction" which can be relied upon to change color after a predetermined number of seconds.

Place 1 ml. of 0.5 N solution of HIO_3 and 100 ml. of filtered starch solution in the pitcher; 1 ml. of 0.5 N solution of H_2SO_3 with 100 ml. of starch solution in the glass.

Both acids are best obtained by acidifying 0.5 N solutions of their salts. $NaIO_3$ is easily obtained; this requires 99 gms. per liter for a 0.5 N solution, or 4.95 gms. for 50 ml., which is a convenient amount. Acidify with H_2SO_4. $NaIO_3$ may require heating to accomplish its solution.

H_2SO_3 is prepared from either $NaHSO_3$ or Na_2SO_3 and freshly boiled water. For $NaHSO_3$ use 52 gms. per liter, or 2.6 gms. for 50 ml. to make a 0.5 N solution. For Na_2SO_3 use 31.5 gms. (anhydrous salt) per liter, or 1.6 gms. for 50 ml. Acidify with H_2SO_4.

The final solutions are mixed in equal volumes and should give the blue color in about one minute. Time can be shortened by increasing the amount of H_2SO_3 used. Note that temperature is also a factor. The success of this stunt depends largely on the freshness of the starch solution. If this is properly made, the color change is instantaneous and startling.

30. Water, III.

Milk of sulfur reaction. Place 10 ml. of saturated solution of $KHSO_4$ in the glass, about 200 ml. of $Na_2S_2O_3$ (hypo) solution in the pitcher. About 4 gms. of hypo in 200 ml. of water should give the milky color in the desired time, about 20 seconds. Increasing the concentration of the hypo shortens the time.

31. Water, IV.

Phenolphthalein reaction. Place 1 ml. of concentrated NaOH solution in the glass, several hundred ml. of dilute H_2SO_4 in the pitcher. Concentrations should be so adjusted that about 200 ml. of acid neutralize 1 ml. of the base. The acid solution should contain enough phenolphthalein to give a decided pink when made basic.

32. Water, V.

The pitcher contains about one liter of pure water. It should be opaque, so that its contents are not visible. The first glass is empty. It is used by Prof. V. for drinking purposes. The second glass contains a few drops of solution of a ferric salt, acidified to prevent hydrolysis; either the chloride or the nitrate may be used. The third glass holds a few drops of a *fresh* concentrated tannic acid solution. The fourth glass contains enough of a saturated solution of oxalic acid *(Caution: poison)* to discharge the color produced by the other two; 10 ml. should be enough.

33. "Hard Water"

This is solidified alcohol. The bottle marked "Hard Water" contains 95% ethyl alcohol. The beaker contains a saturated solution of calcium acetate. Calcium acetate is less soluble in hot water than in cold. About 39 gms. of the salt will saturate 100 ml. of water at 50° C. The best proportions to secure immediate and complete solidification are: one volume of the saturated solution of calcium acetate to nine volumes of alcohol.

34. Inflammable Ice

Solid alcohol, from demonstration 33, ignites spontaneously in contact with *dry* chromic anhydride. Note that the chromic oxide on the anvil is the red anhydride, CrO_3, not the ordinary green oxide, Cr_2O_3.

35. For Washing Hands

A fairly concentrated solution of some ferric salt is placed in the basin — the nitrate is good. A little acid with it will retard hydrolysis, but avoid an excess, as acid on the hands will destroy the soap bubbles in the next demonstration. The towel is soaked in a concentrated solution of KCNS or NH_4CNS, then dried.

As alternatives, potassium ferrocyanide or tannic acid may be used on the towel in powder form, giving blue and black, respectively; but these stains are harder to remove from the hands. Oxalic acid *(Caution: poison)* is helpful for the purpose.

36. Explosive Soap Bubbles

This is the same demonstration as No. 20, but the method of exploding

the bubbles is different, and more dangerous. The detonating mixture of hydrogen and oxygen is highly explosive. The heat generated by the explosion will burn the hands, unless care is taken that the bubbles are *thrown*, not held in such a way that the resulting steam is trapped under the hands. A much safer method would be to simulate the second hand-washing and transfer the bubbles to the flame by means of a spatula with an insulated handle.

It is not recommended that hydrogen be generated in improvised apparatus for this demonstration. Since the object is to end the show with a spectacular stunt or a loud bang, if tank hydrogen is not available use illuminating gas to blow the bubbles, or produce the noise in some other way.

Chem Quiz: Who Was the Man?

_____ Reaction	_____ Hypothesis
_____ Prism	_____ Metal
_____ Salt	*Bunsen* Burner

➤ EACH of the five blanks represents the name of a man. Each phrase is one familiar to chemists, like the example given at the end of the list. You are more apt to know what these men are famous for than to know details of their lives.

THE MAN	DATES	NATIONALITY	OCCUPATION	FAMOUS IN FIELD OF	YOUR SCORE
A	1799-1862				
B	1604-1668				
C	1871-1935				
D	1768-1851				
E	1785-1850				
Bunsen	1811-1899	German	Prof. Chem.	Flame & Heat Study	?
SCORE	20	15	10	5	

The letters A B C D E represent the names of the scientists necessary to complete the phases at the head of this Quiz, but are arranged in a different order. If you can guess the names and identify them by their life dates in the above table, give yourself a score of 20 for each, a total of 100%. If you cannot identify them, turn to page 32 for additional data.

Chemical Surprises

by Joseph H. Kraus

➤ The following reactions are suitable either for stage tricks or for serious laboratory demonstrations. While there are many others that might be included, we have left out many that require elaborate set-ups, or that are too odorous to be done except under a hood.

If a program of chemical tricks is to be constructed, they should be so arranged that the less spectacular come first, gradually leading up to the most spectacular. This has little relation to the difficulty of performance or the amount of technical skill required to perform them.

Burning Ice

➤ Effect: Small lumps of solid material are dropped on a large cake of ice. This may be done under cover of a pass with the hand. A flame is applied cautiously near the surface. The entire block of ice takes fire and burns more brightly as the reaction reaches its height.

Secret: The lumps are ordinary calcium carbide. The surface of the ice should show a bit of moisture. When the lumps are dropped on the surface acetylene gas is given off which will burn. As it does so more water is melted and more gas given off from the reaction. This experiment is reasonably safe if a small quantity of calcium carbide is used. Flames can be extinguished by smothering with a blanket or the carbide is allowed to consume itself.

Burning Solids

➤ Effect: Small lumps of material are placed on an asbestos sheet. When other lumps are dropped on the first material a spontaneous ignition takes place.

Secret: The first material is red phosphorus. It should be handled cautiously and spread gently, without friction. *(Caution: do not use fingers.)* A few iodine crystals are dropped from a long handled spoon on the surface of the phosphorus. A short period of time is required before the reaction starts, *but be sure to have your hands out of the way when it does.*

Caution: Phosphorus burns are very painful and do not heal readily.

Antimony Trails

➤ Effect: A substance is heated with a blow torch, then dropped on paper on which it leaves decorative curved and radiating patterns.

Secret: The substance is antimony metal which is heated either in a small crucible or on a block of charcoal having a depression in it. A large sheet of paper at least four feet square is placed on a level table and the molten metal is dumped in the center.

Because of its high surface tension the metal runs in every direction, the tiny balls of the molten metal leaving a star pattern with many rays extending in all directions.

If the paper sheet is folded to form a shallow cone and this is then set into a box to support it, an entirely different design replete with solid, dashed and dotted curves will result. In this case the molten antimony is

poured onto the cone about half way to the center. The balls of molten metal will race off, down one side and up the other in the most graceful of curves.

For heating the antimony, a mouth blowpipe and Bunsen burner will give good results. Temperature required, 650° C.

Hot Stuff

➤ EFFECT: A sheet of copper or silver is heated to redness and lowered into a beaker containing a water clear liquid. Instead of cooling, the entire copper sheet continues to glow at a bright yellow heat and shows what appear to be flames constantly shifting on its surface.

Secret: The liquid at the bottom of the beaker is acetone. The copper sheet, which may measure many square inches, should be about four inches long for best effects. It should be suspended by iron wires from a glass rod supported across the mouth of the beaker.

One end of the copper sheet is heated to redness and the sheet is immediately lowered into the beaker where it hangs about a quarter of an inch above the surface of the liquid.

As long as the acetone vapor is in contact with copper — or silver — it continues to cause the metal piece to glow. Instead of copper, a silver coin such as a half dollar may be used, but it will be ruined during the experiment. The copper sheet should have about the same thickness as a half dollar for best results.

Phosphine Rings

➤ EFFECT: A glass flask is fitted with a delivery tube the open end of which is beneath the surface of water in a large beaker. Bubbles of gas ignite when they break at the surface of the water and leave behind perfect rings of smoke.

Secret: It is the less stable hydrides which ignite the phosphine when this gas comes in contact with the air. A 500 ml. flask is fitted with a two hole stopper and two delivery tubes, one of which is long enough to reach under the surface of a large beaker half full of water. The far end of the tube should be bent so that it turns upward toward the surface of the water.

The flask contains normal potassium hydroxide into which is dropped a piece of white phosphorus about the size of a pea. Illuminating gas is permitted to pass through the system to drive out the air, then the shorter delivery tube is closed off by pinching the hose. Heat the solution to boiling. This demonstration is most showy if the background is a black screen.

Caution: Do not open the generator, because an explosion may occur. Instead, to shut off the apparatus, fill the beaker with water and shut off the heat. As the flask cools, water from the beaker will be carried in. This also avoids the escape of the poisonous fumes.

Spontaneous Combustion

➤ EFFECT: A black powder is poured out of a test tube onto a sheet of asbestos. It takes fire immediately. Fanning with the hands makes more of the material burn. When the asbestos sheet is tipped there is a cascade of flame given off with huge quantities of smoke. The powder may

be dumped on the palm of the hand by an experienced experimenter, and thrown into the air.

Secret: Lead tartrate is put into a pyrex test tube fitted with a one holed stopper. The test tube is held almost horizontally and heated until no further fumes are given off, and the material turns black. Care should be taken in heating to avoid spilling the powder. It tends to build up into heaving gas filled mounds.

While still hot the test tube is corked with a solid stopper and allowed to cool to room temperature. When this cool material comes into contact with the air it bursts into flame. The fumes are choking and neither the demonstration nor the preparation should be attempted except outdoors or in an exceptionally well ventilated room.

(Caution: Do not transport the material in anything except well protected tubes. A broken tube may result in a dangerous fire. Observe usual fire precautions.)

Bouncing Putty

➤ Effect: The Chemagician makes a white mass which looks like putty. It can be drawn out into lengths, pressed together again and rolled into a ball. If the ball is thrown forcibly against the floor it bounces, yet if it is allowed to remain in one spot it flattens like a peppermint wafer.

Secret: The bouncing putty is made by diluting commercial waterglass or sodium silicate with a little more than its own volume of water. Stir for good mixture. This can be prepared beforehand or the entire lump of putty, actually a gel, can be made during the demonstration. Denatured alcohol is added to the silicate solution slowly and with constant stirring until a heavy mass forms.

Remove the mass and wash under running water, kneading the mass all the time. Wash hands often. The mass is elastic to quick forces and plastic to slow forces.

The putty will remain good for several days. It should then be thrown out, so that it will not be mistaken for something edible.

(Caution: Use some cold cream on the hands after making the putty, to prevent chapping of skin.)

Snow Fall

➤ Effect: An artificial landscape is set on a surface and covered with a bell jar or an inverted aquarium. After a few minutes snow will be seen to fall and cover the entire scene, clinging beautifully to the branches of the "trees" and "rooftops."

Secret: A small electric heater, or an alcohol lamp or Bunsen burner, is hidden behind some of the scenery or concealed within a model structure. On this is placed a small cup with about a teaspoonful of benzoic acid. Small model houses, a mirror to represent a lake or stream, twigs and stones are arranged to give an artistic effect.

At the proper moment the current to the heater is turned on. Soon the "snowflakes" will be found to be settling down and forming a beautiful snowscene.

If the cover of the model scene is removed while the benzoic acid is being heated, "snow" will fall all over the room. While the benzoic acid is easily cleaned up, most people would object to this as a practical joke.

Fanning Into Color

➤ EFFECT: A white cloth flower is exhibited. This is fanned with a sheet of cardboard, or held near an electric fan. The flower blushes, then changes to a deep red color.

Secret: The flower is dipped into a weak solution of fuchsin, then the stem is pushed through a sheet of cardboard. The cardboard is inverted over a wide-mouth bottle containing about a half inch of strong ammonia. The flower remains suspended in an atmosphere of ammonia gas.

Just before the experiment is to take place the flower is removed. When placed in an air stream the ammonia evaporates and the color change takes place. The flower may be passed around for examination after all the ammonia fumes have been dispelled.

Liquid to Solid

➤ EFFECT: The Chemagician shows several test tubes filled with a clear liquid. He defies the spectators to uncork the tubes and pour the contents into beakers. He also warns them that at command the contents of the cold tube will get very hot. Spring clothespins make good holders for the hot tubes, and should be provided.

Secret: The test tubes contain a supersaturated solution of ordinary hypo made by adding as much hypo to boiling water as the water will take. The hot solution is then poured into test tubes which are corked and allowed to cool to room temperature. For a quicker reaction it is well, sometimes, to push a single crystal of hypo into a slit cut in the bottom of the corks which are used to cap the tubes.

When the cold tubes are passed out care must be taken to disturb them as little as possible. The demonstrator then tells his spectators to shake the tubes at the given signal, hold them tightly so as not to spill the contents and keep one finger on the cork during the shaking proces, then uncork and pour. Seeding the solution with the tiny crystal results in immediate crystallization of the entire contents of the tube with the evolution of considerable heat.

The crystal state can be restored to a liquid and the trick repeated merely by heating the tubes in a water bath.

Another Chameleon Liquid

➤ EFFECT: Water from a clear glass pitcher is poured into seven apparently empty glasses and turns into colors as it fills the glasses.

Secret: The water in the pitcher is prepared by addition of six drops of potassium hydroxide and 24 drops of concentrated potassium ferrocyanide to each quart. This should leave the water clear.

Each glass is prepared by the addition of a single drop of a concentrated solution of the following chemicals. If the drops are spread the performer can invert the glass to show that it apparently is empty and unprepared.

Pyrogallic acid gives a light brown color
Silver nitrate or lead nitrate gives "milk," (do not use both)
Ferrous sulfate gives dark green
Copper sulfate gives red-brown
Mercuric nitrate gives light yellow
Nickel nitrate gives greenish white
Phenolphthalein gives scarlet

Get rid of glasses immediately after the trick because some of the colors

are precipitates and will settle rapidly. For best results, swirl glasses to get a better mixture.

One and One Isn't Two

➤ EFFECT: Two quarts of what appears to be water is mixed in a pitcher. When the contents of the glass pitcher again is returned to the quart bottles it is found that the quantity is less than it was before, and the quart containers are not full.

Secret: One of the quart bottles contains water; the other contains alcohol. Denatured alcohol may be used. Scientists explain the effect by stating that the molecules of the two liquids intermingle.

One and One Makes Zero

➤ EFFECT: Two test-tube gas generators are set side by side. One of the gases is collected in a wide-mouth bottle by downward displacement of water. When gas from the other generator is permitted to run into the bottle reddish-brown fumes appear and the water is again drawn up into the bottle. The experiment may be repeated several times.

Secret: The test tubes are arranged on the same stand, each fitted with its own rubber stopper and delivery tube. The collecting bottle of quart size or larger is filled with water and placed in a water trough. The first test tube contains potassium chlorate and manganese dioxide, for the typical method of producing oxygen. Other methods for supplying this gas may be used instead. The second tube contains copper filings and nitric acid for producing nitric oxide. The first will require heat to give a satisfactory supply of oxygen; the second need not be heated.

Nitric oxide is collected first. When the bottle is nearly full, the tube from the oxygen supply is brought under the inverted mouth of the jar. Instantly red-brown fumes will form. The gas thus formed is nitrogen peroxide which is highly soluble in water. Because of this the water rises in the collecting bottle. When nearly full of water the oxygen supply is removed and the trick repeated. This can be repeated a number of times.

Dry Water

➤ EFFECT: The Chemagician drops a half dollar into a bowl of water and states that if anyone will remove it with the bare hands, without getting the hands wet, he may have the coin. He demonstrates that he can do so.

Secret: Before dipping his hands into the bowl the Chemagician picks up about a quarter teaspoonful of lycopodium powder. This is obtainable from an old-fashioned drugstore. In making passes over the water in the bowl he drops the powder onto the water. It floats.

When the hand is dipped into the water the lycopodium coats it like a glove. The hand will come up perfectly dry although the coin will be wet.

Dust Flash

➤ EFFECT: The demonstrator blows dust from a drinking straw toward and somewhat above a burning candle or lamp. Instantly there is a large, yellowish flash of light as the finely divided particles take fire.

Secret: The material in the straw is lycopodium powder, which bursts into flame when finely divided. Half fill the straw with the powder, and blow with an atomizer bulb so that

the powder will be shot into the air about a foot or two above an open flame and the same distance in front of it. *Don't blow with breath. There is danger of burning your face.*

Dust Explosions

➤ EFFECT: A gallon tin can with press on cover has a little dry powder dumped into it. It can be shown that the powder will not burn well. A candle mounted inside the can is lighted, the cover is put on quickly and a snappy puff of air from a connected tube blows the powder around inside the can. There is a loud explosion and the cover flies up into the air.

Secret: A small pill box is fitted to the bottom of the can. A tube is soldered so that it connects to the inside of the pill box. This in turn is connected to a rubber hose and mouthpiece or atomizer bulb.

Half a teaspoonful of lycopodium powder is put into the pill box. The lighted candle is set on a shelf or block so that the flame is near the top. The puff of air blows the lycopodium all over the inside of the can. Ignition of the powder results in considerable expansion of gas which, because of the confined space, results in an explosion.

Modification of this effect is to make a cardboard house, or building and show by destruction of the structure what happens in a dust explosion in a grain elevator or mine. Other dusts besides lycopodium will work, but we have not found any which gives such consistently good results.

Caution: Watch the lid as it falls.

Chem Quiz: On the Scent

➤ ONE OF the interesting features of organic chemistry is the work-out your nose gets—and not always an unpleasant one, either. Here are the names of some compounds in one column and in the other, in scrambled order, the things they smell like. Can you match them? If not, they are blended harmoniously on the answer page.

acetamide	hyacinths
amyl acetate	almonds
amyl valerate	strawberries
benzaldehyde	garlic
ethyl butyrate	pineapples
ethyl formate	bananas
ethyl sulfide	wintergreen
methyl cinnamate	peach kernels
methyl salicylate	apples
phenyl acetaldehyde	mice

Additional Data on Chem Quiz: Who Was the Man?

➤ WHO WAS HE? His Nationality was: A—English; B—German; C—French; D—Scotch; E—English; Bunsen—German. Write these facts in the spaces on page 26 and see whether you can now identify the scientists you couldn't place before. If nationality was necessary to tip you off, record your score as 15 for each guessed from this data. If you still have some unidentified, turn to page 48 for occupational clues.

Putting On a Show

► If your club, class or school plans to produce a play for any occasion, it is important that certain details be followed if you expect success.

All types of plays may use scientific properties. Even the simplest skit may be embellished with one or more of the stage effects described in this book.

You may select a play which comes to you in finished form — possibly one which has had a successful run on Broadway. At the other extreme, you may decide to write your own. Or you may adapt ideas from other sources to your own local conditions. A high school group will often find this the most satisfactory plan, for they can work in timely references and local jokes.

This book is designed to offer helpful suggestions in working up such a show. There is plenty of local talent among your own group, if you strike the spark of enthusiasm to kindle it.

If you plan to work up your own show, call a discussion meeting of all who are interested. If any members of the group already have definite ideas in mind, they may be asked ahead of time to write them out in rough draft and bring them to the meeting.

In the discussion, someone usually speaks up and offers a certain episode as good material. Someone else adds to it. The director may then ask if these people would like to work it up in the form to be used. Usually they would, and there is one act the director can count on.

Others will follow. Soon the need will be for cutting, to keep the best parts but stay within the time limit for the show.

Perhaps the most difficult type of play to direct is the musical comedy. It calls for many assistants, stage scenery, costumes, good musical voices, an orchestra, dance routines, and a large cast.

Most of this large group of people are all too likely to horse around during rehearsals while the director is working with the principals of the cast.

Somewhat easier to produce, and more encouraging to the cast, because so many play leading roles, is the old fashioned vaudeville show. Here the principals work singly or as small teams. Each act uses the talents of the individuals for the parts to which they are best suited.

Use can be made of good dancers, musicians, gym teams and amateur magicians, as well as dramatic talent and natural comedians. The director should try for a well rounded performance, with a little bit of everything.

Each of the acts should rehearse independently. The director will then bring together two or three groups at a time, to cue the transitions from one act to the next. He will not call up the entire cast, perhaps, until the final rehearsal. This stimulates interest and a feeling of suspense among the cast, who will not feel that the show is an old story by opening night.

Assume that the decision has been made to give some sort of performance. The director is chosen for natural aptitude plus a certain amount of previous experience in dramatic production. From that moment, it is up to him (or her) to see that parts are assigned to those best fitted for them and to plan the production of a satisfactory performance.

Casting

Those who have good singing voices are singled out, if the performance is to contain song. Those with knowledge of chemical procedures are selected if the performance is to be a chemical demonstration. Those without any particular abilities for the leading roles are sent scurrying for props and materials to be used in the play, or are set to work making posters, selling tickets, making scenery, or are assigned duties in scene shifting. Work can always be found for the whole crowd, no matter how many there are.

Many factors enter into choosing the person for the part. Good health and good marks are both valuable attributes for the leading character. It is mighty sad when the best voice, the most charming girl, the most brilliant student or the cleverest wit is given a minor part in the play because of poor attendance or low classroom grades.

Yet, when the whole performance depends upon the presence of the star, the director must be sure that the pupil who takes that part can be depended upon to be there and to carry the role.

While it is possible that the pupil with low grades may make a good showing in memorizing a part in the play, the odds are against his carrying out the performance brilliantly. Furthermore, a somewhat backward student cannot afford the time the rehearsals will take from his classroom or home work.

So, consider scholastic attainments and a record of steady attendance in addition to your evaluation of the student's ability to play the part. But personal likes and dislikes, social position and parental influence should be completely eliminated in arriving at your decisions about the members of the cast.

A good director will assume command immediately. He should be willing, of course, to accept criticism and suggestions, but these must not be allowed to interrupt rehearsals. Several assistants or volunteers should be spotted in different parts of the hall where rehearsals are taking place, each provided with pad and pencil to jot down places where improvements can be made. A conference after rehearsal can decide how these suggestions can best be utilized.

The Stage Crew

If scene shifts are to be made, pay particular attention to those responsible for the stage changes. These teams must be fast and accurate. Plan staging so that turns requiring simple settings are in front of a drop while scenery is being shifted behind it.

The stage crew will work stocking-footed, and often in poor light. Their part needs as careful rehearsing, often, as that of the players seen by the audience. Let them work with the cast during rehearsals. Their cooperation in arranging stage effects may well be vital to the play.

While "prima donna" tactics may perhaps be condoned from an outstanding star, amateur performances cannot tolerate clash of personalities. Just as every link is necessary for fashioning a chain, so everyone's part is essential to the whole performance. After all, the play's the thing. Nothing should be allowed to interfere with its successful completion.

Rehearsals and Staging

At the first rehearsal, parts are given to the players. They are stationed on the stage, with chairs and other props (or substitutes for them) in the approximate positions they will occupy at the performance.

Each player reads his or her part, and goes through the fundamental action. It will be slow and monotonous, so break it up into several portions.

It is important that the director instruct the players properly at the first rehearsal. Don't permit any player to memorize a part until after the first rehearsal. There is no sense in letting a player memorize a part only to discoverer that the inflections, actions, tone of voice, and other necessary details will have to be unlearned again. If you start right, your plays will fall into final form, and only last minute polishing will be required.

Polish should be completed in the last two or three rehearsals with the entire cast, orchestra and lights. Dress rehearsal with complete costumes and make-up takes place the day before the performance.

Center of Action

Unless you are staging a three-ring circus, only one action should be under way at any one time. A player should let his actions come naturally, yet he must always consider the audience. Except on very rare occasions, and for a good reason, no player ever turns his back on the audience.

Hand motions can be modified so that the hand away from the audience is the one which is in motion. This is a good general rule, but it should not be carried too far. A right-handed person makes poor use of his left hand, for example, to shoot a pistol or crack a whip.

If the object which is to be manipulated is to be seen by the audience, the actor should stand with his right side toward the audience. If there is to be sudden, concealed action, the left side is toward the audience. In either case, the object is held in the right hand.

Sound

Few things will unnerve an audience as much as words that cannot be understood, either because they are not spoken loud enough to be heard or because the subject matter is beyond the grasp of the audience.

Even a stage whisper must be heard by the person farthest from the performer. One fact, often lost sight of, is that the voice sounds louder in an empty auditorium during rehearsal than when the same space is full of people on opening night.

Then there are always disturbing influences in the audience, coughing, shuffling feet, squeaking seats and the like. The player must speak loud enough to make it easy to be heard.

If you are to have a microphone to amplify the sounds you utter, it should be so placed that it will not

hide your face. Do not talk directly into it, for it is sensitive enough to pick up the sounds of inrushing air as you take a breath, and transmit blasts and hisses as air escapes from your mouth.

You should be able to speak naturally near the microphone, and your voice should sound normal to the audience. When speaking, don't rove from the instrument unless the stage is set to pick up sounds from all quarters. Stay within arm's length, and the control operator can adjust to gain the proper amplification without booming.

Chemical Manipulation

It will be conceded that a stage show needs rehearsal. Also a sleight-of-hand performance.

A program of chemical tricks needs rehearsal even more. The operator must be thoroughly familiar with the experiment he is performing, and his every motion must be smooth and sure. If he becomes rattled, there is real danger of an accident, and no chemical manipulation, even as simple a one as striking a match, is without some hazard.

Just as a good cook never experiments when there is company for dinner, but sticks to a menu of her frequently-tried specialties which always turn out right, the chemical magician will put into his repertory only the tricks he is sure of.

There is something about the excitement of watching an experiment that makes the audience perversely want it to fail. Perhaps the people out front subconsciously resent the implication that the man on the stage knows more than they do.

Whatever the reason, this attitude can often be felt by the experimenter. It creates one more reason for him to work carefully and rehearse again and again.

Although the tricks and effects described in this book are standard recipes that have been used many times, readers cannot be too strongly reminded that fire is hot, broken glass is sharp, and reacting chemicals are not to be handled carelessly.

Study your set-up including not only stage but auditorium and exit facilities, for fire hazards. Stay not only within the letter of your local law but away from every possibility of serious trouble. Better a dull show than a regrettable accident.

Use no more of the chemicals than the directions call for. Handle them carefully. Don't try any practical jokes with them. Don't try to put on one of the elaborate shows, with rapid-fire timing, as given in this book, until you have familiarized yourself with the techniques of much simpler demonstrations.

Practically any one of the demonstrations listed in this book is interesting enough to be used alone as the highlight of a laboratory open-house or a school assembly program, while more elaborate combinations of them can be worked up as the experimenters gain skill and experience.

The three plays in this book have all been given successfully before appreciative audiences. They may be followed verbatim. An even better plan would be to use one or another of them as the type of play you wish to put on, and then modify it by working into it the experiments you are prepared to perform, plus plenty of local color to please your audience.

Assembly Demonstrations

by Burton L. Hawk

Experiments may be performed before an audience either to mystify or to explain. Chemical principles are illustrated by either kind of demonstration, but in the following experiments the emphasis is on making clear the reason behind the reaction.

In putting on an assembly demonstration, staging is no less important than in performing tricks merely to amuse the audience. Full use of such devices as spot-lighting the reaction, against a background of a contrasting color, will make the effect easier to see from the last row in the auditorium. A bit of showmanship on the part of the demonstrator will also help in getting instruction across before a large audience.

Ink

➤ Many years ago, when I was a lad, my introduction to chemistry was brought about by the acquisition of a small chemical set. A thoughtful Santa Claus brought the outfit one joyful Christmas. With youthful enthusiasm I leafed anxiously through the instruction book - - - "how to change wine into water" - - - "how to change water into milk" - - - "water to blood and blood to stone" - - -. But I was a little disappointed. This wasn't *real* wine or *real* milk or *real* blood - - - only make believe. I wanted to make the genuine article. But, wait, what was this? "How to Manufacture Ink." And *real* ink! One measure of this and one measure of that in half a test tube of water. Shake with thumb over mouth of tube. Quickly, find a pen. And it works! The ink actually writes! I immediately informed the family that they need no longer purchase ink - - - I would proudly supply the family's needs! That was many years ago.

Nowadays the manufacture of ink is a highly specialized industry. We have inks that write under water, washable inks, permanent inks, wet inks that write dry, dry inks that write wet, and hundreds of other types. The inks we describe here are not the modern specialized types. But, nevertheless they are of good quality and will serve well for all practical purposes.

Blue Ink

Prussian blue (ferric ferrocyanide) provides the coloring pigment for this ink. Dissolve 1 gram of ferric ammonium sulfate in 10 cc. of water. Dissolve 2 grams of potassium or sodium ferrocyanide in 15 cc. of water. Mix the two solutions, filter and thoroughly wash the precipitate. Then add just enough oxalic acid solution to dissolve the precipitate forming a syrupy liquid. Finally, thin with water and your ink is ready for writing.

A dilute solution of Prussian Blue in oxalic acid is also used as laundry bluing.

Black Ink

The color for our black ink is derived from the reaction of ferrous sulfate on nutgalls. Nutgalls are obtained from the twigs of various

species of Quercus which grow in Asia Minor. Nutgalls are comprised chiefly of tannic acid, with a smaller percentage of gallic acid, ellagic acids and resin.

Boil 7 grams of nutgalls in 30 cc. of water for at least one hour. Add water as necessary to replenish that lost by evaporation. Filter the solution and while still hot, add 2 grams of ferrous sulfate and 1 gram of gum arabic. Heat again to dissolve all solids, and then filter once more.

Red Ink

The color here is obtained from the dried bodies of insects, of all things. Cochineal, Coccus cacti, is found in Central America and Mexico. The dried female insect with the young larvae is used. Chemically it consists of carminic acid, coccerin, and fat.

Place 2 grams of cochineal in 20 cc. of water and heat to boiling, shaking occasionally. Then remove from flame and allow to cool thoroughly, stirring frequently. When cold, add a solution of 2 cc. ammonium hydroxide in 6 cc. of water. Allow to stand overnight; then filter.

Green Ink

Dissolve 5 grams of copper acetate and 3 grams of potassium bitartrate in 20 cc. of water. Allow the solution to boil gently over a low flame for about 30 minutes. Then filter. If too thick, add a small quantity of water.

Purple Ink

We have used twig growths and dried insects; now we shall use wood chips. Logwood or hematoxylon is the heartwood of a Central American tree of the senna family. It contains about 10% hematoxylin with some tannin and resin.

Boil 3 grams of logwood in 12 cc. of water until the solution is colored deep red. Then add 3 grams of aluminum sulfate. Boil again for about 10 minutes and while still hot, add 1 gram of gum arabic. Finally, filter the solution.

Commercially, aniline dyes are replacing the natural dyes in most inks. But, perhaps you will find it interesting to prepare the inks by the old-fashioned "natural" method, as I first did - - - many years ago.

Solutions and Solubilities

➤ A HOMOGENEOUS mixture of two or more substances, in which the proportions of said substances usually can be varied only to certain limits, is known as a solution. In other words, if you stir a little salt in a glass of water it will dissolve. The salt is distributed evenly throughout the water and, in general, its properties are extended evenly to all portions of the solution. In other words, the water is salty.

Now only a limited quantity of a substance will dissolve in a solvent. When all the substance that will dissolve has been added, we have what is known as a saturated solution. But there are some substances which will overdo their dissolving capacities. Under certain conditions more than the limited quantity will dissolve, and we then have a *super*-saturated solution. Like an over-inflated balloon, the continued existence of a super-

saturated solution as such is rather uncertain. As a slight strain will cause the balloon to burst, so a slight disturbance will cause the substance in a super-saturated solution to separate out.

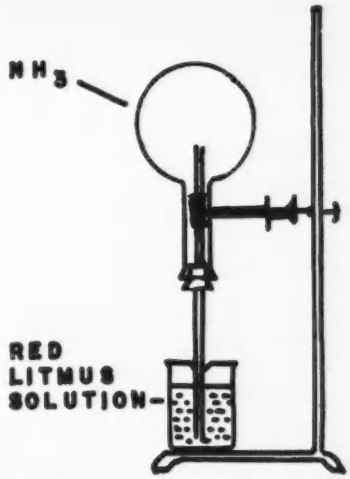
Supersaturation makes an interesting demonstration. A super-saturated solution in a large beaker is standing on the table. From all appearances, it is a beaker of water. Then a small crystal is dropped in the solution, or it is touched with a stirring rod. Suddenly a large quantity of crystals separates out of the solution with amazing speed and soon the liquid turns mysteriously to a solid.

To prepare your super-saturated solution; use sodium thiosulfate, or photographer's hypo. For every 10 cc. of hypo, add only 2 or 3 drops of water. Heat gently until a clear liquid is formed. Then cover the container loosely and allow to cool. Be careful not to shake or jar the container. If crystals are formed, try again using a few additional drops of water. If desired, the solution may be cooled by immersing the container in cold water.

Gases Dissolve

Gases, as well as solids, are soluble in water. One striking example is that of ammonia gas. Under normal conditions, one volume of water will dissolve about 700 volumes of ammonia. This amazing solubility can be demonstrated in a fascinating experiment.

First the ammonia is prepared by pouring ammonium hydroxide on solid sodium or potassium hydroxide in a flask and applying gentle heat. Fill a large Florence flask with the gas by inverting it over the generator



➤ For the ammonia *fountain, the tubing should extend about two-thirds the way down beneath the surface of the liquid in the beaker. Be sure you have enough liquid in the beaker to be able to fill the flask at least one-half full.*

flask. The ammonia will rise into the empty flask, as it is lighter than air. Of course, it will not be necessary to warn you to keep the gas away from your eyes. When you feel that the flask is filled with ammonia, remove it and, keeping in inverted position, insert a one-hole stopper containing a length of glass tubing. Immerse the other end of tubing in a beaker of water colored with red litmus. (see diagram) Gradually, the water will be drawn up the tube and when it reaches the top, it will spurt forth forming a spectacular fountain. The red solution will be colored blue by the alkaline reaction of the ammonium hydroxide.

If no explanation is offered, this will prove most baffling to an unscientific audience. The flask can be filled with ammonia ahead of time and securely stoppered. You will hint to the audience that it is simply an empty flask. And to further your point, you can invert the flask and remove the stopper to prove there is nothing in it. (Don't turn it right side up or the "nothing" will escape.) The water rising in the tube is contrary to all laws of gravity, and the fact that the red liquid suddenly turns blue for no apparent reason adds to the mystery.

Oxidation—Reduction

➤ Do you realize that when you strike a match you are witnessing a process of combustion, oxidation and reduction? And do you realize that during this process thousands of electrons are lost by certain atoms and simultaneously gained by other atoms? And that the result of all this commotion is the release of energy in the form of light and heat? If you hold the match long enough, you will be very much aware of the latter form of energy.

What we are leading up to is that oxidation is the loss of electrons. Reduction is the direct opposite, or the gain of electrons. Now the generous substances that give away the electrons are known as *reducing agents* and in the losing of electrons they are *oxidized*. On the other hand the greedy substances that grab the electrons are known as *oxidizing agents* and in the getting of electrons they are *reduced*. In order to further complicate matters, let us cite an example:

$$2SO_2 + O_2 \rightarrow 2SO_3.$$

In this reaction, the elemental oxygen has a valence of zero. In the sulfur trioxide (SO_3) it has a valence of —2. In other words, it gains two electrons; therefore it must be an oxidizing agent and is reduced itself. The sulfur in the sulfur dioxide has a valence of +4, and in the sulfur trioxide +6. A gain of two positive charges means it loses two electrons; therefore it must be a reducing agent and is oxidized itself.

Nitric Oxide

The oxidation of nitric oxide, NO, to nitrogen dioxide, NO_2, makes an interesting demonstration. An apparently empty flask covered with a glass plate is placed on the table. At the opportune moment, the plate is removed and the flask is suddenly and mysteriously filled with brown fumes. What happened? The colorless nitric oxide is oxidized to the brown nitrogen dioxide by the oxygen of the air: $2NO + O_2 \rightarrow 2NO_2$. The gas is prepared in a generator flask and collected over water. Place a quantity of mossy zinc in the flask and pour in a mixture of 10 ml. con. nitric acid in 40 ml. of water through the thistle tube. Wait until all brown fumes disappear; then collect the colorless gas.

Flame

Sometimes the oxidation-reduction reaction is so rapid that the mixtures burst into flame. We have already cited one example of this in the burning of a match. But as an audience would hardly get excited over the striking of a match, we must devise something a bit more spectacular.

Potassium permanganate is a powerful oxidizing agent — it eagerly

grabs electrons. In fact it grabs electrons from some substances so fast that an explosion or a flame results.

Place 6 drops of glycerin on a metal plate. Sprinkle about one gram of potassium permanganate on top of it. Soon the mixture will start to sizzle, then smoke, and finally burst into a bright purple flame.

Ammonium Nitrate

Ammonium nitrate is another strong oxidizing agent. We can demonstrate its ability in this capacity as follows:

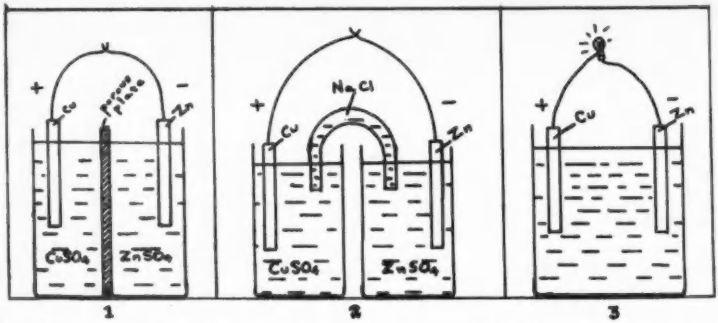
Prepare a mixture of one gram of ammonium nitrate and 0.1 gram ("a pinch") of ammonium chloride. Place the mixture on a small metal plate. Sprinkle evenly over the top of it, 2 grams powdered zinc. Now to start the oxidation; add just one drop of water. Then wait. Nothing will happen at first. Gradually smoke will appear and the mixture will suddenly burst into a brilliant green flame. This old reliable experiment always makes a hit with the audience. You will explain that we scientists use water to start fire. Have an ordinary drinking glass of water on the table. And to prove that it is actually water, drink a small portion of it. Then, with a medicine dropper, take a drop of that remaining to start the fire.

Sulfur Dioxide

Sulfur dioxide is a reducing agent —it releases electrons. It will reduce pink potassium permanganate solution to a colorless solution. Here is another opportunity to baffle the audience. Fill a flask half full of dilute potassium permanganate solution. Fill another dry flask with sulfur dioxide gas. This is done by adding dilute hydrochloric acid to sodium bisulfite. Hold the empty flask inverted over the mouth of the generator flask for a few moments. Stopper securely and place out of sight of the audience. When ready for the demonstration, remove the stopper from the flask and present it in full view of the audience as an "empty" container. Then pour in some of the pink potassium permanganate solution. It will mysteriously turn colorless. (You must work rapidly before sulfur dioxide gas escapes.) To add to the general confusion, you might bring out several empty flasks along with the sulfur dioxide. Pour a little permanganate solution in to each one. Then let your audience figure out why the solution turns colorless when added to one "empty" flask but not to the others.

Electro-Chemistry

➤ One of the greatest accomplishments of science has been the harnessing of the electron with its resultant benefit to all mankind. In the atom, electrons are constantly spinning about the nucleus held within their orbit by the attractive force of that nucleus. By applying energy to the atom it is possible to increase the speed of these electrons and even to knock them out of their orbits into space. In a copper wire, for instance, the electrons freed from one atom will knock out electrons from the adjoining atom. The process is repeated with amazing rapidity throughout the



length of the wire. This constant orderly surge of electrons constitutes a flow of *electricity*.

The simple mechanical energy of rubbing is sometimes sufficient to cause a flow of electrons. To demonstrate, rub a glass rod with a piece of silk, which action forces some of the electrons in the rod to jump to the silk. The rod having lost an electron (negative charge) is now positive. The silk having gained an electron (negative charge) is now negative. If the two objects are brought together, without friction, the opposite charges will attract, the electrons consequently will move back to their original places and an electric current will flow.

Comb your hair vigorously for a few minutes; then hold the comb about $\frac{1}{4}$ inch away from a small steady stream of running water from the spigot. The stream of water will bend toward the comb, and by moving the comb you can curve the stream of water in any direction you wish.

Electro-Chemical Cells

Another method of producing electricity is by chemical reaction; this is the method with which we are primarily concerned.

One type of cell is based on the replacement of copper by zinc: $Zn + Cu^{++} \rightarrow Zn^{++} + Cu$. However, the zinc must not be allowed to be in direct contact with the copper. To accomplish this, a porous plate is inserted in a large container so as to form two separate partitions (Figure 1). A strip of zinc is immersed in a solution of zinc sulfate on one side of the plate and a strip of copper is immersed in a solution of copper sulfate on the other side. The porous plate will prevent mechanical mixing of the solutions, but will not interfere with the passage of ions. Now if a copper wire is connected to the two electrodes, an electric current will flow through it.

If desired, two separate containers can be used for this cell as shown in Figure 2. The inverted U-tube is filled with sodium chloride solution which will permit the passage of ions.

Now just what is happening? When the metals are immersed in the solutions, they tend to form ions and consequently electrons are released: $Zn \rightarrow Zn^{++} + 2$ electrons. However zinc is much more anxious to make this change than is copper. Result: we have a surplus of electrons

around the zinc which constitutes a difference of potential. The electrons then flow along the zinc through the wire to the copper. Here they form copper atoms from the cupric ions: $Cu^{++} + 2$ electrons $\rightarrow Cu$.

Many other chemical reactions can also be used to produce an electric current. For example, sodium chloride solution can be used in both partitions of the cell. One solution is then saturated with chlorine and a stick of carbon is immersed therein. A strip of zinc is immersed in the other solution and the two connected with a wire. Here the energy is produced by an oxidation-reduction reaction. (Zinc is oxidized, chlorine reduced). The electrons, released by the zinc, pass through the wire to the carbon pole where chloride ions are formed from the chlorine atoms:

$$Cl_2 + 2 \text{ electrons} \rightarrow 2Cl^-.$$

(For quick demonstration purposes, it is possible to obtain an electric current by inserting electrodes in the same solution. Simply mix the copper and zinc sulfate solutions in one container and add a little sulfuric acid. Insert the metal strips (zinc and copper) but do not allow them to touch [Figure 3]. We were successful in lighting a flashlight bulb with this set-up.)

Dry Cell

The dry cell utilizes solid materials in its construction instead of liquids. A zinc cup serves as the electrode. This is lined with porous paper to separate it from the solids within. The "solids within" consist of a moist mixture of manganese dioxide, ammonium chloride, some zinc chloride, and a porous inactive filler. A carbon rod is inserted in the center of the mixture which acts as the positive pole. Here the zinc is oxidized (loses electrons) to zinc ions and the ammonium ions are reduced (gain electrons) to ammonia and hydrogen: $2NH_4^+ + 2$ electrons $\rightarrow 2NH_3 + H_2$. The ammonia reacts with the zinc ions to form complex zinc-ammonium ions and the hydrogen reacts with the manganese dioxide as follows: $MnO_2 + H_2 \rightarrow MnO + H_2O$.

Electronics

In addition to passing through solids, electrons may also pass through a vacuum and through rarified gases with many startling results. The study of the properties of electrons in this capacity is chiefly the interest of the physicist, but we feel a few brief remarks here will be of interest.

When a metal filament inserted in a vacuum tube is electrically heated, electrons are emitted. When another metal strip ("plate") is inserted in the tube and charged positive, it will draw all electrons to it. Sometimes a third metallic element ("grid") is inserted between the filament and plate. A positive charge on the grid will speed up the electrons and a negative charge will slow them down. Here we have the basic essentials of the electron tube and with variations we have the radio tube, amplifier tube, rectifier tube, etc.

Some metals, such as cesium and rubidium, emit electrons when subjected to light, the amount of electrons emitted depending upon the intensity of light. These electrons can be concentrated, amplified and converted into high-frequency oscillations which in turn can be transmitted through space by radio waves. Thus

we have one of the basic principles of television.

When certain gases are bombarded with electrons, energy is given off as light—the basis of the familiar "neon" signs.

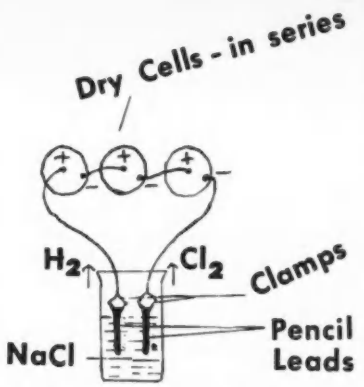
In addition to mechanical motion, heat and light, electrons can also produce sound. The tone of such an instrument as the Hammond Organ is created by the amplification of electrical impulses into sound waves. This remarkable instrument is capable of producing some 253,000,000 different tones!

Electrolysis

We have discussed the formation of an electric current as a result of chemical reaction; now we will investigate the effect an electric current has on chemical compounds.

This is not a novel idea. Sir Humphrey Davy thought of it more than one hundred years ago. His research in the field of electro-chemistry was highlighted by the isolation of the alkali metals. After several unsuccessful attempts to decompose aqueous potash solutions with an electric current, Davy used potash in igneous fusion. When an electric current was passed through the compound, amazing things began to happen. There was violent effervescence throughout with the formation of small globules, or in Davy's own words:

". . . . at the negative surface, there was no liberation of elastic fluid; but small globules having a high metallic lustre, and being precisely similar in visible characteristics to quicksilver, some of which burnt with explosion and bright flame as soon as they were formed, and others remained and were merely tarnished and finally covered by a white film which formed on their surfaces."



➤ Apparatus *set-up for experiments with electrolysis.*

We can well imagine how excited and joyous Sir Humphrey Davy must have been. Here was a new powerful force — the electric current. How would it react on other substances? Could additional elements be isolated? Indeed they could, for following in rapid succession sodium, barium, strontium, calcium, magnesium and lithium were isolated by means of the electric current. And using the sodium and potassium prepared by electrolysis the elements zirconium, titanium, cerium, thorium, beryllium, boron, silicon, and aluminum were isolated.

Source of Current

But let's get back to the home lab. Of course, a direct current is required for these experiments. Three or four dry cells may be used or two 3-volt "utility" batteries. The storage battery from the family automobile is also

satisfactory. If you have access to alternating current, you may use a rectifier or battery charger to convert the alternating to direct. If you use dry cells, connect them in series, that is, the positive terminal of one cell to the negative of the other. For the electrodes, use small carbon rods. Pencil leads will serve very nicely in this capacity.

Aqueous Sodium Chloride

Let us briefly consider a solution of sodium chloride. We have positively charged sodium ions and negatively charged chloride ions migrating throughout the solution. In addition the water provides a small quantity of ions—positive hydrogen and negative hydroxol. To summarize, the solution contains Na^+, Cl^-, H^+, and OH^-.

When the two electrodes from a source of electricity are immersed in this solution, what happens? Well, as you might expect, the positively charged ions (Na^+, H^+), are attracted to the negative electrode and the negative ions (Cl^-, OH^-) to the positive electrode. The hydrogen ion removes an electron from the negative electrode and thus becomes a hydrogen atom. The sodium ion, however, is much more reluctant in accepting electrons and will not do so unless forced to by a greater current of electricity.

Meanwhile the negative ions (Cl^-, OH^-) are moving toward the positive electrode. Here the chloride ion loses an electron and becomes a chlorine atom. The more selfish hydroxol ion will not readily give up its electron and hence remains in solution 'status quo.'

Now we have hydrogen released at the negative and chlorine at the positive. The sodium and hydroxol ions remaining in solution combine with each other forming a solution of sodium hydroxide.

To demonstrate the above, simply electrolyze a salt solution to which a few drops of phenolphthalein solution have been added. Almost immediately the solution will turn pink indicating the presence of sodium hydroxide. (If your salt solution turns pink upon addition of phenolphthalein before electrolysis, use potassium chloride or chemically pure sodium chloride. This alkaline reaction is probably due to the presence of magnesium carbonate added to table salt to keep it "pouring when it rains."). As electrolysis is continued you will be able to detect the odor of chlorine. Some of the chlorine dissolves in the solution and reacts with the sodium hydroxide forming sodium hypochlorite:

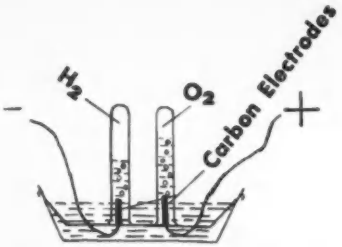
$$2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O.$$

This mixture of salt and sodium hypochlorite is known as *Javelle Water*, sold commercially as a bleach for the home laundry. It is also useful as an antiseptic, sodium hypochlorite being an efficient bactericidal agent.

Thus with salt solution as our starting point, we obtain hydrogen, chlorine, sodium hydroxide, sodium hypochlorite, and Javelle Water.

Electrolysis of Water

There are two general methods of acquiring knowledge: (1) by studying the opinions and findings of others; (2) by actual experience and personal observation. The latter method is particularly applicable to the study of science.



Let us consider the composition of water. We have read in chemistry textbooks that water consists of two parts hydrogen and one part oxygen. This is simply accepting the findings of others; let us actually *prove* this statement to our own satisfaction.

The best way to determine the composition of a substance is to decompose it into its component parts and then identify each one. With water, we can accomplish this by electrolysis.

As water does not conduct the electric current, a small amount of sulfuric acid must be added to make a conducting solution. Set up an apparatus similar to the one shown. A shallow pan or trough is filled partly with the solution. Two test tubes or narrow bottles are also filled and inverted in the solution in the trough. Finally the electrodes from a source of direct current are inserted — one in each tube. Four dry cells should provide sufficient current for this demonstration. The electrodes should be of platinum, but if your supply of this metal is exhausted, strips of carbon (pencil leads) will suffice.

As electrolysis is begun, you will notice bubbles of gas arising from the electrodes which will gradually displace the water in the tubes. You will notice also that twice as much gas is obtained from the negative electrode as from the positive. If the textbooks are correct, this must be hydrogen.

Finally, when all water is displaced, stopper the tubes quickly and then remove from the solution. Now we should have hydrogen in the negative tube and oxygen in the positive. Invert the tube of hydrogen, remove the stopper, and hold over an open flame. A sharp explosion will confirm the identity of hydrogen. Remove the stopper from the oxygen tube and quickly insert a glowing splinter. The splinter will burst into flame thus proving the presence of oxygen.

Therefore in reality we have proved that water consists of hydrogen and oxygen in the ratio of 2 to 1. We have learned something through personal observation and findings. Such is the purpose of experimenting.

Metals by Electrolysis

By passing an electric current through a solution of silver nitrate, metallic silver can be obtained. Allow the carbon electrodes to dip in the solution. You can actually see crystals of silver growing on the negative rod.

Copper may be obtained in a similar way from copper sulfate solution. In fact, most of the less active metals can be obtained in this manner: lead, tin, mercury, gold, etc.

The metals will always be liberated at the negative pole. Can you determine by experimentation alone (without reference to any text books) what is liberated at the positive pole?

The more active metals cannot be liberated from their aqueous solutions by electrolysis. As we explained, the electrolysis of sodium chloride solution will not produce sodium. Here it is necessary to electrolyze the

sodium chloride in a molten state to obtain the metal. This requires an extremely high temperature and a strong current of electricity and is not recommended for the home lab.

Commercially, both sodium and chlorine are produced by the electrolysis of molten salt. Potassium is obtained by the electrolysis of molten potassium hydroxide.

Calcium, barium and strontium can also be obtained by electrolyzing the fused chlorides.

Aluminum is obtained by the electrolysis of a solution of aluminum oxide in fused cryolite.

Magnesium can be obtained by electrolyzing a fused mixture of magnesium, sodium, and potassium chlorides; or by electrolysis of magnesium oxide dissolved in fused magnesium fluoride.

Thus we see the important role electricity plays in the production of many vital metals.

Our study of electrolysis would not be complete without a consideration of electro-plating. Chemists have brought the beauty and durability of rare and expensive metals within the reach of everyone by this simple process of coating an inexpensive metal with a thin layer of a more valuable one.

For electroplating, only a small direct current is required. Two or three dry cells should be sufficient. The object to be plated is made the cathode, and a strip of the pure metal to be deposited is made the anode. The whole is immersed in a solution of a salt of the metal to be deposited.

The metal to be plated must be thoroughly clean and free of grease. Scrape any rust or corrosion with a wire brush or steel wool. Then immerse in a boiling solution of washing soda. Finally, place in a "pickling bath" of dilute sulfuric acid.

Copper Plating

The size of the object to be plated will determine the quantity of the electrolytic bath required. The entire object should be immersed in the solution.

For every 25 cc. of water, use approximately one gram of copper sulfate. Better results are obtained if a small quantity of gelatin is added to the solution. Attach a strip of pure copper to the positive wire of your cell and the object to be plated to the negative wire. Immerse both wires in the copper sulfate solution, but do not allow them to touch.

The thickness of the plate will depend upon the strength of the current and length of time employed. You must use your own judgement to determine when a proper plating is attained.

Nickel Plating

Proceed as above, using for the electrolyte a solution of nickel ammonium sulfate—about one gram to 25 cc. of water. Add to this solution a small quantity of ammonium chloride, boric acid, and gelatin. The anode in this case will be a pure strip of nickel. Try nickel plating a copper penny.

Cobalt Plating

Although not practiced widely commercially, it is possible to plate with cobalt as well as nickel. The electrolytic solution is the same as that for nickel with cobalt chloride used in place of nickel ammonium sulfate. And, of course, cobalt metal must be the anode.

Zinc Plating

As you probably know, zinc is used to form the protective covering on galvanized iron. The zinc can be applied by spraying the molten metal on the iron, by dipping the iron in the melted zinc, or by electroplating. For the latter method, a solution of zinc sulfate is used.

Chromium Plating

Because of its brilliant lasting luster, hardness, and resistance to corrosion, chromium is perhaps the most popular of electro-plated metals.

Articles to be plated with chromium are usually nickel plated first. The electrolyte is a solution of chromic acid (chromium trioxide), and the anode is pure chromium. Chromic acid is a powerful oxidizing agent and must be handled carefully.

Silver Plating

In plating with silver, the metal is liable to be deposited as a large spongy mass or a loose powder. In order to prevent this, potassium cyanide is added to the plating bath to cause the silver to plate out more slowly. With silver nitrate the complex silver-cyanide ion, $Ag(CN)_2$, is formed. This ion is only slightly ionized thereby reducing the concentration of silver ions in the solution; hence the metal is deposited more slowly and evenly.

To a solution of silver nitrate, add about one-half as much potassium cyanide and a small quantity of gelation or glue. Now we must pause for a word of caution. *Remember—the poisonous qualities of potassium cyanide have not been exaggerated!* You *must* be careful! Wash all utensils immediately after using. Do not allow the liquid to spill on your skin. Do not allow the cyanide to come into contact with any acid.

Proceed to electroplate as with previous metals using a small piece of pure silver as the anode.

Gold Plating

If you can afford it you can also gold plate by using a solution of gold potassium cyanide (*poisonous!*), or a solution of gold trichloride (chloroauric acid), $AuCl_3 \cdot HCl \cdot 4H_2O$.

* * *

There are many "tricks of the trade" in electroplating. Type of current, strength of current, type of bath, composition of article to be plated, concentration of bath, etc. all play an important part in the quality of the finished product. By working carefully, taking your time, and trial experimenting, you will soon be in a position to do a good job of plating on many household articles.

Chem Quiz: Who Was the Man?

➤ WHO WAS HE? His Occupation was: A—Metallurgist; B—Selling Nostrums; C—Professor of Chemistry; D—Mineralogist; E—Physician and chemist; Bunsen—Professor of Chemistry.

Add these facts to the outline on page 26, and for each new name correctly guessed count 10 on your score. If you still need help, the clues on page 62 should be the give-away.

The Home Lab as a Hobby

by Burton L. Hawk

➤ In a facetious vein, a hobby may be defined as "work without compensation." This may be true, for what may be a hobby for one person may be a means of livelihood for another. However, a good hobby will provide a pleasant diversion which can bring both relaxation and stimulation.

Who

Obviously, the hobby you choose will have to be in a field which occupies your highest interest. We assume that you have an interest in chemistry or you probably would not be reading this article. You enjoy reading magazines and textbooks about chemistry? You liked the chemistry course in high school? And you relished the performing of experiments in the school laboratory? You are fascinated at the revealing of new facts and formation of new substances through research? Then why not construct a lab of your own; perform your own experiments; do your own research? A college degree is not required, neither is it necessary to be a skilled technician. All you need are the *interest* and *desire*. You must not force yourself into it. Perhaps the study of science seems dull to you in detail and you care only to keep posted occasionally on important developments. Then you must pursue a hobby in another field of more interest to you—perhaps music, art, or sports.

A chemist is a strange person. He mixes poison, caustic acids and harsh alkalies. He chokes in pungent mists, coughs and gasps from poison gas, is sickened by vile-smelling vapors. Yet in this he finds real joy and stimulation!

Why

The ever-changing and constantly growing science of chemistry provides unlimited experimentation. Certainly work in the home lab will not be monotonous. When you consider that absolutely *everything* that exists is the result of a chemical reaction, you can realize the magnitude of this science. Consider also that *one element*—carbon—is capable of producing 300,000 known compounds and it is still possible to prepare thousands of others!

The complexity of chemistry presents a challenge, which taxes the ingenuity of man. This brings fascination and mystery, for a subject easily mastered just as easily becomes tiresome.

Chemistry is a young science, still rapidly growing. There are still many unexplored paths to follow, many things that need explanation and clarification. There will always be something new. Certainly the study of chemistry will not lack stimulation.

How

By now the question may arise as to how a home lab can be established. First a suitable location must be found. A corner in the cellar would probably be best, preferably near a window. Running water and gas would be convenient but not absolutely necessary.

Next, find or construct a suitable work bench. The basic requirements are that it be sturdy, of convenient height, spacious, and covered with a suitable washable material, such as linoleum or a slab of marble. If you have running water available, you would allow space for a sink at one end of the bench. If not, keep a large pitcher of water handy and a bucket or large jar for waste. Or if you wish, you can construct a siphon arrangement. Shelves can be built on the wall next to or in back of the table.

Now you are ready to stock your lab. It is rather difficult to list what should be purchased at first. Perhaps the best thing would be to purchase one of the many chemistry sets on the market today—for about five or ten dollars. This will provide you with a varied selection of the more common chemicals. From time to time, purchase more chemicals and apparatus and in this way gradually enlarge your laboratory without too much financial trouble. Start from the bottom; you cannot expect to obtain a well-equipped laboratory overnight.

At first, perform simple experiments. Later purchase a good textbook and perform some of the experiments described in it. Experiments appear periodically in many scientific journals such as those in this series—designed primarily for the home lab.

As your laboratory progresses, so you will progress to more difficult and fascinating experiments. Soon you will find that you will be performing experiments of your own — following miniature projects of your own. Here you will experience a new kind of pleasure, a creative pleasure, the joy of discovering things for yourself!

Some may question the danger of a home lab. A home lab is no more dangerous than any other hobby, if you simply abide by one principle: *Use common sense!* Naturally, you will handle corrosive liquids and dangerous poisons carefully. You will provide yourself with adequate protection when experimenting with explosive mixtures. And of course you will not expose inflammable liquids to open flames. Do not mix everything together, "to see what will happen." Think out your experiments before performing them. Investigate the subject and deduce what will happen—then proceed with proper preparations.

Neatness is an important factor. Nothing is more discouraging than an untidy, unkempt lab. Keep all of your chemicals properly and neatly labeled and arranged on the shelves in systematic order so that you may locate them quickly. Wash all dishes after each experiment and keep all apparatus clean. Dirty containers can spoil many experiments.

Finally, got to it and have fun! Learn all you can and observe all you can. Remember some of the greatest discoveries were made by young men experimenting in home-made laboratories! America needs scientists—and well may the home lab enthusiast of today become the scientist of tomorrow!

CHEMISTRY regulars have been following Burton L. Hawk's experiments "For the Home Lab" for several years. We reprint here selections from this popular series so that readers may have them in ready reference form.

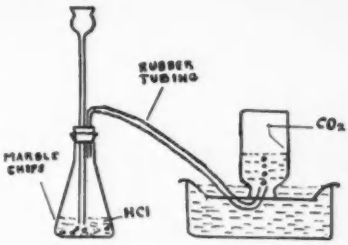
Fun With CO_2

➤ Considering the adage that all work and no play is not good for anyone, we propose to present experiments this time to be performed primarily for pleasure. We feel that the average chemistry student is studying too hard; he should have a little relaxation. We also realize that chemistry is a serious subject to be studied seriously, but fortunately, it does have its lighter moments.

Now carbon dioxide is an amiable substance to use for our diversion. It is not poisonous, does not explode, and has no odor; therefore it will not be necessary to drive the rest of the family out of the house while we are experimenting.

The formation of carbon dioxide is very easy. Simply exhale. That this CO_2 is as good as any other CO_2 can be proven by blowing through a glass tube into a solution of lime water. A white precipitate of calcium carbonate will form. Or blow through a weak solution of sodium carbonate colored pink with phenolphthalein. It will turn white. Or better still, blow into a blue solution of litmus and it will turn red. Here is an opportunity for you to show your friends how strong your breath is. But this method of obtaining carbon dioxide will become exhausting, so let us proceed from here by chemical means.

Place a few teaspoonfuls of marble chips (technically, calcium carbonate) in a large flask and cover with water. Fit the flask with a stopper containing a delivery tube and thistle tube. Since carbon dioxide is heavier than air, you may prepare it by downward displacement of air. Or, if you prefer, it

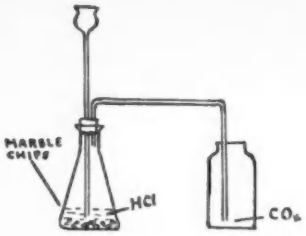


can be collected over water. Pour hydrochloric acid through the thistle tube and collect several bottles of the gas. It may be necessary to add more acid from time to time to insure an even flow of gas.

Did you know that carbon dioxide supports combustion? Neither did we, because it doesn't. But some active metals will continue to burn in it. To demonstrate, ignite a piece of magnesium ribbon and thrust it into a bottle of carbon dioxide. It will continue to burn and soot will be formed. Now as the laboratory manual would read: "Why? How? Write the equation. Calculate the weight of magnesium required to completely reduce one liter of CO_2. Explain." However, since we mentioned before that this was to be a pleasurable experiment, you may ignore above questions.

If you have ever had a chemistry set, you are probably familiar with the stunt of pouring carbon dioxide over a lighted candle. The flame will be extinguished, seemingly by holding an 'empty' bottle over it.

Place a dry container of CO_2 on the table. Remove the lid just before



you are ready to perform the experiment. Now prepare a solution of blue litmus. Pour the blue solution into the jar of CO_2 and shake. It will mysteriously turn red. This is most baffling to one not familiar with the deep complications of chemistry. Let your unsuspecting friend try the trick. Direct him to pour the blue solution into an empty bottle. He can shake all day, but it won't turn red. Next you pour the solution into another bottle (note: your bottle contains CO_2) and the color changes.

The next trick requires much patience. First it is necessary to fill a small shallow pan completely with carbon dioxide. Connect a rubber hose to your generator leading to the bottom of the pan. Allow gas to flow into the pan for quite some time. Now, while gas is still flowing in, blow a few soap bubbles and direct them so that they float easily down into the pan. If sufficient gas is in the pan, the bubbles will float on top of it, dancing mysteriously in mid air. Why? How? Explain. Write the equation.

Solid CO_2

Carbon dioxide is very easily liquified. If this liquid, under pressure, is allowed to escape into a cloth bag, the evaporation and expansion cause absorption of heat and part of the liquid solidifies. This solid CO_2 is widely used as a refrigerant under the name of *Dry Ice*.

You can prove that dry ice is carbon dioxide by placing a piece in a dry flask. Attach a delivery tube leading into lime water. As the solid sublimes, the CO_2 will bubble through the lime water and turn it milky.

Place a solid stopper in the flask—not too tightly—and see how long it will take the expanding gas to blow it out.

The same stunts described for CO_2 gas can also be performed using solid CO_2. However, do not pick up the ice with your bare hands; always use gloves or tongs.

(Note: The above experiments are described solely for pleasure. Any information received from them, new or old, is entirely coincidental.)

Speed of a Chemical Reaction

➤ Let us consider, for a moment, a crystal of common salt. It is composed of sodium ions and chloride ions held together by the powerful attraction of opposite charges—positive and negative. When this crystal is dissolved in water, the ions are separated and are free to combine with other ions that may be introduced. If a solution of silver nitrate is mixed with a solution of sodium chloride, a white precipitate is formed *immediately*, thus illustrating the incredible speed of the reacting ions.

Another example of the speed of chemical reactions can be shown read-

ily in a fascinating experiment. Sometimes known as the "iodine-clock," this experiment may be familiar to you. If so, we ask that you forgive repetition for the sake of others who have not yet performed it.

Two Solutions

Two solutions are required. Solution A is made by dissolving 1 gram of potassium iodate in 500 ml. of water.

But, you do not have potassium iodate? Then, simply manufacture your own! Now if potassium chlorate can be made by the action of chlorine on potassium hydroxide solution, is there any reason why iodine cannot be used similarly to produce potassium iodate? No reason at all. Add 1 gram of iodine crystals to 20 or 30 ml. of warm potassium hydroxide solution. Heat if necessary to dissolve all the crystals. The reaction is: $3I_2 + 6KOH \rightarrow KIO_3 + 5KI + 3H_2O$. You will note that potassium iodide (KI) is also formed. Evaporate the solution nearly to dryness; the iodate, being less soluble, will crystallize first. Or better still, heat to dryness and dissolve the entire residue in alcohol (either grain or wood alcohol). The iodide will dissolve, leaving the iodate, which can be obtained by filtering and carefully drying.

Using another line of thought, if potassium iodate is KIO_3, is there any reason why it cannot be prepared by oxidizing potassium iodide—KI? No reason at all. Mix a solution of potassium iodide with a solution of potassium permanganate, the latter in excess, and heat to boiling for a few minutes. The reaction is: $KI + 2KMnO_4 + H_2O \rightarrow KIO_3 + 2KOH + 2MnO_2$. Filter off the brown precipitate (MnO_2) and evaporate the filtrate to dryness. Alcohol will dissolve the KOH, leaving the iodate.

Now we are ready for solution B. Dissolve 0.2 grams of sodium bisulfite in 450 ml. of water. Add to this 3 ml. of molar sulfuric acid. (In case you have forgotten, a brief explanation may be in order. A *molar* solution contains one gram-molecular weight of the solute in 1 liter of solution. The gram-molecular weight of sulfuric acid is 98 ($H_2 = 2$; $S = 32$; $O_4 = 64$) —therefore 98 grams in 1000 ml. or approximately 50 grams in 500 ml. or 1 gram in 10 ml. represents a molar solution. The specific gravity of sulfuric acid is 1.84, meaning 1.84 or approximately 2 grams occupy 1 ml.; thus 1 gram of acid in 10 ml. would be equivalent to 1 ml. of acid in 20 ml. of solution. Therefore add 1 ml. of acid to 20 ml. of water . . . and why didn't we say this in the first place?). Also add 50 ml. of starch suspension, made by dissolving 1 gram of starch in 50 ml. of hot water. Cool thoroughly before adding.

Mixture Turns Black

Now mix equal quantities of the two solutions. After about 20 or 30 seconds the liquid will suddenly turn blue-black without any apparent reason or cause. This appears rather baffling to those not acquainted with chemistry, which is the reason for the popularity of the experiment as a public demonstration stunt. The demonstrator, through experience and careful preparation of solutions, knows exactly when the solution will darken in color. He places the colorless liquid in view of the audience. At the exact movement he waves a "magic" wand

over the vessel and the colorless solution turns black.

How It Happens

If you are a true scientist, you will want to know why the solution behaves as it does. We shall attempt to satisfy your curiosity.

When the solutions are mixed, iodic acid, HIO_3, and sulfurous acid, H_2SO_3, are formed which immediately react with each other: (1) $HIO_3 + 3H_2SO_3 \rightarrow HI + 3H_2SO_4$. As fast as the hydriodic acid (HI) is formed, it reacts with the unused iodic acid present forming free iodine: (2) $HIO_3 + 5HI \rightarrow 3I_2 + 3H_2O$. The free iodine immediately reacts with any unused sulfurous acid to form hydriodic acid again: (3) $I_2 + H_2SO_3 + H_2O \rightarrow 2HI + H_2SO_4$, and thus the cycle continues until all the sulfurous acid is used. The free iodine then remains in solution and with the starch forms the intense blue-black color. The first reaction is slower than the last. The time required for the three reactions to reach completion accounts for the lapse of time before the change of color. The speed of the reactions can be increased by concentration or by heat.

With practice and patience, you can develop this experiment into an art. By diluting or concentrating the solutions involved you can bring about the color change at any time you wish.

If sodium bisulfite is added to the blue solution it will become colorless again. The supply of sulfurous acid is thereby replenished, and the free iodine combines with it (reaction 3 above).

This experiment vividly illustrates the remarkable regularity and intricacy that exist in the infinitesimal world of ions and molecules! Who would think that in the innocent-looking solutions there is a raging inferno of reactions—combining and re-combining, crashing and colliding back and forth with unimaginable speed!

Pineapple Oil From Butter

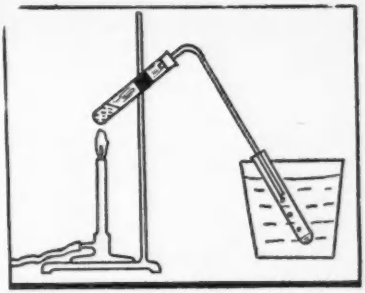
➤ THE CHEMISTRY LAB has so long been associated with evil smells and acrid vapors that many have lost sight of the fact that the chemist is also capable of reproducing many of nature's more pleasant aromas. The essences of wintergreen, pineapple, apple, pear, banana, grape, etc. are just a few of the many that can be made in the laboratory.

The preparation of essence of pineapple from butter creates an interesting experiment which can be performed rather easily in the home lab. In fact the most difficult part of the experiment is obtaining the butter. If you are one of the fortunate few who have access to a small quantity of the precious substance, and wish to donate it in the interest of science, you may proceed as follows:

Place one teaspoonful of butter in an evaporating dish and heat gently until melted. Now weigh out approximately one gram of potassium carbonate and add it in small portions to the melted butter. It is necessary to stir constantly with a glass rod. Keep your face away from the mixture while heating as the fumes may be

somewhat irritating. After the potash has been added, continue to heat the butter to boiling for several minutes. This process is known as *saponification*. Our chief concern with butter here is the glyceryl butyrate content, which we are attempting to extract in the form of potassium butyrate. Most butters contain about two per cent of glyceryl butyrate, which is a compound of butyric acid and glycerin. It has the formula: $C_3H_7.CO.O.CH_2.CH(OH).CH_2OH$.

Our next step is to acidify the butter mixture. After it has boiled for a few minutes, remove it from the flame and add a *small* quantity of dilute sulfuric acid, stirring constantly. Keep adding the acid in small quantities until reaction ceases, which will indicate the solution is acid. The solution should now be distilled. This can most conveniently be done with two test tubes. Pour the butter mixture into one of the tubes, and place a one-hole stopper in it containing a glass tube extending into a second test tube which is immersed in a tumbler of cold water. Heat the butter mixture gently until one-half the mixture distils over. The distillate should now contain a solution of butyric acid. By adding sulfuric acid to the butyrate salt, butyric acid, being more volatile, is set free. It boils at 162°, and condenses in the cool distillate tube. Butyric acid has an unpleasant odor similar to rancid butter ($CH_3.CH_2.CH_2.CO.NH_2$.).



Now add a few ml. of ethyl alcohol to the distillate and an equal quantity of con. sulfuric acid, and distil the mixture once more, being careful not to heat the liquid too strongly. The distillate will contain an appreciable quantity of essence of pineapple which can be easily detected by its odor. It is a welcome product after working with the rancid odor of butyric acid.

Chemically, essence of pineapple is known as ethyl butyrate: $CH_3.CH_2.CH_2.COOC_2H_5$. Pure ethyl butyrate is a colorless liquid boiling at 120° with a specific gravity of 0.879. It is soluble in about 150 parts of water, and is miscible with alcohol, which solution is known as "artificial oil of pineapple."

Now if laughing friends deride, when acrid smoke gets in their eyes, you can take the pineapple oil from the shelf, and prove to them yourself, that the versatile chemist can create sweet soothing savors as well as evil-smelling vapors!

Oil of Bitter Almonds

➤ In the kernels of various fruits such as cherries, peaches, plums, apricots, etc., there is a substance which is called *amygdalin*. Now this substance is hydrolyzed by *emulsin*, an enzyme, into benzaldehyde, hydrocyanic acid and glucose—a mixture which has a fragrance of bitter almonds. All of

which would be very fine if it were not for the presence of a rather objectionable personality — hydrocyanic acid—public poison No. 1. Benzaldehyde, on the other hand, has the almond flavor and is not poisonous; therefore we will favor its preparation.

Benzaldehyde belongs to the series of organic compounds known as *aldehydes*. Some examples of aldehydes are acetaldehyde, a first cousin of acetic acid, and the familiar formaldehyde, a relative of formic acid. Following this line of thought, can you determine the acid cousin of benzaldehyde?

Benzaldehyde may be prepared in many ways:

(1) By oxidation of toluene with manganese dioxide and sulfuric acid.

(2) By reducing benzoyl chloride with nascent hydrogen.

(3) By the hydrolysis of benzal chloride.

(4) By boiling benzyl chloride with aqueous lead nitrate solution.

(5) By the action of a Grignard reagent (a compound of an organic halide and magnesium, such as CH_3MgI, C_6H_5MgBr, etc.) on ethyl formate.

(6) By the destructive distillation of a mixture of calcium benzoate and calcium formate.

Assuming that the average home lab is not supplied with a variety of the less common organic chemicals, we chose the last method of preparation. Calcium benzoate and formate can easily be prepared from the respective acids.

Prepare a solution of benzoic acid by dissolving a few grams of the acid in 25 ml. of boiling water. Then add as much calcium carbonate (precipitated chalk) as will dissolve in the boiling solution. Add in small quantities. Filter the solution while still hot to remove any undissolved solid and evaporate the filtrate to dryness to obtain crystals of calcium benzoate.

Calcium formate is prepared in the same manner using a hot, dilute solution of formic acid (see below) instead of the benzoic acid. Be careful not to spill formic acid on the skin. It produces painful burns.

Equal quantities of the two chemicals, thoroughly dried, are intimately mixed and placed in a dry test tube. Clamp the tube in an inclined position on a ring stand and fit it with a one-hole stopper and delivery tube extending to another test tube which is immersed in cold water. Heat the mixture evenly. Benzaldehyde will be formed and will pass over and condense in the cool receiving tube. It can be readily recognized by its bitter almond odor.

Benzaldehyde, $C_6H_5 \cdot CHO$, when pure is a colorless, refractive liquid boiling at 179°. It is not very soluble in water, but is readily miscible with alcohol and ether. It is widely used in the manufacture of dyes and perfumes. If you have the patience to collect a moderate quantity of benzaldehyde, place it in a bottle, stopper tightly, and save for future experiments.

Preparation of Formic Acid

➤ IF A SUPPLY of formic acid is not available, you can prepare it from oxalic acid and glycerin. Place 5 ml. of glycerin in a small flask and add 3 g. of oxalic acid. Fit the flask with a 2-hole stopper, carrying a delivery tube extending to a receiving flask which is externally cooled. Insert a thermometer through the other hole in the stopper, allowing it to immerse in the glycerin. Heat the mixture *slowly* to 110°, when formic acid will pass over and condense in the cool receiving flask. Then allow the mixture to cool; add more oxalic acid and heat again to 110°. Repeat this procedure until you have obtained a sufficient quantity of formic acid. The acid obtained is entirely satisfactory for preparing calcium formate as described above.

Remember, one trait the home chemist must possess is that of versatility. If you lack certain chemicals needed to perform an experiment, don't fret—learn to manufacture the desired chemicals from those which are available. It can be done!

Fragrance of Cinnamon

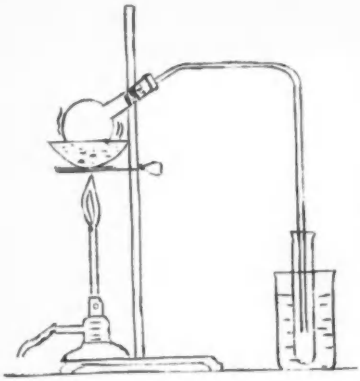
➤ IN THE SOUTH SEA islands of the Pacific, in Asia, and in Ceylon, there grows a plant which yields valuable volatile oils, and which is known scientifically as *Cinnamomum zeylanicum*, or more commonly as cinnamon. The household spice is obtained from the dried bark of this plant which sometimes attains a height of twenty feet. Also, from the bark, leaves and twigs of the plant, there is derived an oil which is used in medicine and as a flavor in foods and in the manufacture of perfumes. But it is no longer necessary to travel to the South Sea Islands to obtain this delightful, tangy flavor, for the practical chemist has created a method of preparing the oil in his own laboratory. Having analyzed the natural oil as a mixture of aldehydes, acetates, acids and alcohols, he found it possible to synthesize the chief ingredient of the oil—*cinnamaldehyde*, which possesses a pleasant cinnamon odor. It can for most purposes be used as a substitute for the natural oil.

Cinnamaldehyde is formed by the action of dilute alkali solution on a mixture of acetaldehyde and benzaldehyde. This is an example of a *condensation* reaction, where two substances combine to form a third one with the resultant elimination of water:

$$C_6H_5CHO + CH_3CHO \rightarrow C_6H_5CH{=}CHCHO + H_2O$$

The dilute alkali acts as the *condensing agent.*

Mix together in a large test tube 5 ml. of acetaldehyde and 5 ml. of benzaldehyde and add 4 ml. of dilute sodium hydroxide solution. Stopper tightly and shake thoroughly for three or four minutes. Then immerse the tube in a solution of cold water, preferably ice water. Continue to shake the mixture occasionally from time to time. Remember, in organic chemistry patience is a virtue. Since organic compounds do not form ions they are slow to react. After about an hour of the ice water treatment, allow the stoppered tube to stand in a cool



DISTILLATION OF ACETALDEHYDE

place for at least twelve hours. At the end of this time a yellowish oily liquid will have formed in the test tube. Separate the oil by means of a separatory funnel or medicine dropper. Do you recognize the spicy odor?

While this experiment may appear relatively simple to perform, you may encounter some difficulty in obtaining the desired product. If such is the case, it may be that the component reagents used were not sufficiently pure. Therefore it is advisable to distil the acetaldehyde and benzaldehyde separately before using them in the experiment. Because of its inflammability and low boiling point, care must be exercised in the distillation of acetaldehyde. Place small quantities at a time in a flask which should be immersed in boiling water. Do not heat the flask with a direct flame. When distilling benzaldehyde, add several pieces of clay plate or glass beads to prevent spurting and irregular boiling. Use both reagents immediately after distilling.

Make Your Own Reagents

➤ IF A SUPPLY of acetaldehyde and benzaldehyde is not available, it is possible to prepare a sufficient quantity of each to perform the above experiment.

The preparation of benzaldehyde was discussed in detail in a previous article of this series. The method described is the destructive distillation of an intimate mixture of dry calcium benzoate and formate.

Acetaldehyde can be prepared by a similar method using a mixture of calcium acetate and formate. These two compounds are easily prepared by neutralizing the respective acids (acetic and formic) with calcium carbonate.

Acetaldehyde is an inflammable liquid, colorless when pure, with a boiling point of 21 deg. It has a pungent odor and should not be inhaled too strongly as it irritates the mucous membranes. It is produced commercially from acetylene which reacts with water in the presence of dilute sulfuric acid and mercuric sulfate as catalyst: $C_2H_2 + H_2O \rightarrow CH_3CHO$. It can also be prepared by the oxidation of alcohol:

$C_2H_5OH + O \rightarrow CH_3CHO + H_2O$.

Fragrance of Hyacinth

➤ DEEP IN THE HEART of every home chemist, whether he admits it or not, is the secret desire to make perfumes! For who does not enjoy a pleasant scent? And for the chemist, who is so familiar with evil smells, the pleasant scent should be doubly enjoyable.

In previous articles we have dealt with the fragrance of fruits, nuts, and spices. Now we shall direct our attention toward flowers. Many compounds can be prepared in the laboratory which duplicate the fragrance of popular flowers and the chemist utilizes these compounds as the basis for synthetic perfumes. One such compound is phenylacetaldehyde which possesses the delightful odor of hyacinths. It is made from cinnamic acid by treatment with hypochlorous acid and dilute sulfuric acid.

Our first step, then, is to prepare cinnamic acid. The famous chemist, Perkin, devised a method of synthesizing the compound by heating together sodium acetate, benzaldehyde, and acetic anhydride. We shall do likewise. Place 2 grams of *dry* potassium acetate in a flask. (It has been found that a better yield is obtained more quickly by using potassium acetate in place of the sodium salt.) Ordinary crystalline potassium acetate can be dried by heating gently in an evaporating dish with occasional stirring until all vapor is driven off and the salt is completely fluid. Allow the mass to solidify, grind to a powder in a mortar, and use immediately. Add to the potassium acetate in the flask 5 cc. of acetic anhydride and 3 cc. of *freshly distilled* benzaldehyde. (When distilling benzaldehyde, add small pieces of clay plate or glass beads to prevent bumping.) Mix the ingredients thoroughly and heat the flask allowing the solution to boil gently for at least a half-hour. If irritating vapors bother you, do not become discouraged. Open a window and carry on! At the end of the designated time, remove the flame and add 10 cc. of hot water to the contents of the flask. Add cautiously; the action may be somewhat vigorous. The mixture should now be steam-distilled until all unchanged benzaldehyde is removed (see below). However, if you do not have the facilities for doing this, it may be eliminated. Merely heat the solution to boiling again for 10 or 15 minutes. Then filter the hot solution quickly and heat the filtrate again to boiling and add a few cc. of hydrochloric acid. Allow the solution to cool, stirring occasionally. Cinnamic acid will crystallize out. Remove the crystals by filtering and redissolve in hot water. Cool and recrystallize. Repeat this operation several times to obtain a purer product.

In describing this experiment we are taking into consideration the limited facilities of a home laboratory. Naturally, a 100% pure product cannot be expected. Much better results can be obtained by using an air-cooled reflux condenser, heating the flask in an oil bath, steam distilling, and filtering with suction. But if such set-ups are not available, the home-chemist must not assume an attitude of discouragement; he must improvise.

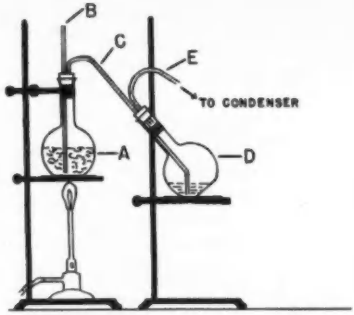
Stir about ½ teaspoonful of bleaching powder (chloride of lime) in 50 cc. of water. Allow the solid matter

to settle, and pour off the clear solution. Prepare a solution of cinnamic acid by adding a small amount of the acid to 10 cc. of hot water. Heat further, if necessary, to dissolve as much as possible. Add to this an equal amount of the clear bleaching-powder solution. The reaction produces a compound known as phenyl-*a*-chlorolactic acid:—C_6H_5 . CH : CH . COOH + HOCl → C_6H_5 . CHOH . CHCl . COOH. Add a small quantity of dilute sulfuric acid to the mixture and heat gently. The result: phenylacetaldehyde: —C_6H_5 . CHOH . CHCl . COOH → C_6H_5 . CH_2 CHO + HCl + CO_2. But what's in a name? . . . that which we call a hyacinth, by any other name would smell as sweet. . . .

The Perkin synthesis of cinnamic acid is another example of a *condensation* reaction, similar to the preparation of cinnamaldehyde, as described in a previous article. But whether the actual condensation takes place with the acetate salt or with the acetic anhydride is a matter open to question. And just how much our patient reader is concerned with how the condensation takes place is also a matter open to question!

Steam Distillation

In many organic experiments, it is desirable to purify compounds by steam distillation. A simple method of doing this is shown in the accompanying diagram. Steam is generated in flask A by heating water and is conveyed via tube C into the liquid to be distilled in flask D. Tube B, extending almost to the bottom of the steam-generating flask, acts as a safety valve. The distillate passes through tube E which leads to a condenser or to a flask immersed in cold water (not shown). Make sure all connections are tight. It may be necessary to heat flask D gently to prevent too much condensation. When distillation is completed, disconnect tube C *before* removing heat from flask A; otherwise contents of flask D may be sucked back into the generator.



Steam Distillation

Essence of Apples

➤ "SAY, OLD CHUM, how about combining our brilliant minds to prepare that apple concoction you were talking about the other day?"

"A good idea, Jack, now that we have some time to spend in the Lab. Now lets see, what was the name of that stuff? Ethyl . . . ethyl something."

"Can't think of ethyl's last name? How about acetate, salicylate, butyrate, oxalate, valerate . . ."

"Ethyl valerate . . . *iso*valerate. That's it! Ethyl isovalerate . . . 'colorless liquid with apple-like odor.' Sound interesting?"

"Quite, I hate to throw in a wet blanket . . . but just how in the world

do we prepare same?"

"Here is where we use aforementioned brilliant mind. We know ethyl isovalerate is an ester similar to ethyl acetate . . . right?"

"Right."

"And we know that ethyl acetate is prepared by the combination of ethyl alcohol and acetic acid?"

"Granted."

"Then is it not in order to assume that the isovalerate ester is prepared by the combination of ethyl alcohol with *isovaleric acid*?"

"What excellent showing of intelligence, old boy! That's downright astoundin'! Just one minor detail I must add."

"Elucidate, fellow scientist."

"We have no isovaleric acid."

"Is that all? Don't let a little thing like that trouble you! We simply prepare our own. Referring to prior conversation on ethyl acetate . . . suppose we had no acetic acid. We could prepare some by oxidation of ethyl alcohol, could we not?"

"Right."

"Well, then, we can prepare isovaleric acid by oxidation of . . . of . . . er—let's see . . ."

"Go ahead . . . oxidation of which alcohol?"

"Pardon slight pause for identification. Here it is, formula for isovaleric acid is $(CH_3)_2.CH.CH_2.COOH$."

"So?"

"So, let us scan the formulas of the more popular alcohols. Do you note any similarity?"

"Ah, yes. The light is beginning to break through. There is iso-amyl alcohol with the formula $(CH_3)_2.CH.CH_2.CH_2.OH$."

"Precisely, old chap. Now fortunately, we can formulate our formula thusly: $(CH_3)_2.CH.CH_2.CH_2.OH + 2(O) \rightarrow (CH_3)_2.CH.CH_2.COOH + H_2O$."

"Good. Now let's stop fooling around and start actual work on the project. I assume chromic acid would be the proper oxidizing agent."

"Absolutely the best. We'll place about 10 cc. of water in the flask and add just about as much sulfuric acid. Now if you will weigh out seven grams of potassium bichromate and add it to the solution . . ."

"No sooner said than done. Now we dissolve, and lo, the chromic acid is ready! Amazin,' eh what?"

"Quite. Now about 3 cc. of isoamyl alcohol should be enough. I hear these reactions are quite vigorous, so I suggest we add the alcohol drop by drop, and shake the flask thoroughly after each addition."

"You are right again. Old chromic acid really goes to town with its oxidation. That flask is really hot! Whew, what an odor!"

"So far so good. Notice the solution is turning green. We had better cool the flask a bit. Immerse it in cold water."

"This certainly doesn't smell like apples to me! More like rancid cheese . . ."

"That's fine . . . just what we want. The cheesey odor is valeric acid. If all the alcohol has been added, heat the mess for about five or ten minutes."

"Open that window! What an odor!

How in the world do we ever get apple flavor out of this brew?"

"Elementary, my dear Watson. This solution evidently contains a bit of valeric acid judging from its B. O. So, we pour a small quantity of it in a test tube, add an equal quantity of ethyl alcohol and distill."

"Assistant to chemist: one-hole stopper attached to test tube containing glass tube leading to another vessel immersed in cool water. Ready for heat."

"Chemist to assistant: apply gentle, even heat."

"Assistant to chemist: no sooner said than done."

"Now you see, assistant, according to all rules and regulations, the liquid being condensed in the receiving tube should be ethyl isovalerate. And furthermore, whereas, according to additional rules and regulations, should have a fragrant odor of apples . . . I wonder if it will . . ."

"I wonder . . ."

Chem Quiz: Who, When and Where?

➤ Here is a list of names outstanding in the history of chemistry. Some of these men you may have met. Some you may never have heard of. Some you may find hard to distinguish from certain others. Their life-dates are in the second column. Can you match the dates and names? For your enlightenment, the identifications are in the back of the book.

1. Baekeland	*a.* (372-287 B.C.)	11. Moissan	*k.* (1778-1829)
2. Berthelot	*b.* (3rd or 4th century A.D.)	12. Paracelsus	*l.* (1779-1848)
3. Berthollet	*c.* (9th century A.D.)	13. Priestley	*m.* (1827-1907)
4. Berzelius	*d.* (1940-1541)	14. Remsen	*n.* (1829-1896)
5. Boyle	*e.* (1577-1644)	15. Rhazes	*o.* (1839-1903)
6. Carothers	*f.* (1604-1668)	16. Smith	*p.* (1846-1927)
7. Davy	*g.* (1627-1691)	17. Thénard	*q.* (1852-1907)
8. Gibbs	*h.* (1733-1804)	18. Theophrastus	*r.* (1852-1911)
9. Glauber	*i.* (1748-1822)	19. van Helmont	*s.* (1856-1928)
10. Kekulé	*j.* (1777-1857)	20. van't Hoff	*t.* (1863-1944)
		21. Zosimos	*u.* (1896-1937)

Chem Quiz: Who Was the Man?

Additional Data on the Scientists called for on Page 26.

A—Anti-friction bearings; B—Preparing inorganic chemicals; C—A method of organic synthesis; D—Work with polarized light; E—Theory of constitution of the elements; Bunsen—Study of heat and flame. For those identified by these final clues, give yourself 5 each. Now turn to the answer section to see whether you are right.

Fireworks and Colored Flames

➤ Of course, all fireworks should be set off outside unless you use very small quantities and do not object to irritating smoke. Best results are obtained on dark, wind still evenings.

All ingredients used must be dry and finely powdered. Powdering should be done in a mortar—*each ingredient separately!* Special caution must be observed when grinding potassium chlorate, as this substance may explode if handled too roughly. The powders are mixed together on a sheet of paper by lightly shuffling with a knife or spatula.

The mixed powders are ignited easily by using touch paper. The latter is made by soaking sheets of filter paper in concentrated potassium nitrate solution. When dry, they are cut into thin strips.

Remember the composition of all the following mixtures is given by parts—not by weights. We suggest that you refrain from using too large quantities.

And finally, the mixtures must be made immediately before using for best results.

Colored Fires

Thoroughly mix the ingredients and pour into a metal pan—a metal screw cap jar lid will be satisfactory. Form a neat pile and ignite with touch paper.

White

6 parts—potassium nitrate
1 part —sulfur
1 part —antimony sulfide

Red

5 parts—strontium nitrate
1 part —sulfur
1 part —charcoal
2 parts—potassium chlorate

Yellow

3 parts—sodium chloride
4 parts—potassium nitrate
1 part —sulfur
2 parts—chaircoal

Green

7 parts—barium nitrate
2 parts sulfur
3 parts—potassium chlorate

Purple

1 part —copper sulfate
1 part —sulfur
1 part —potassium chlorate

These may be made into flares as follows. All ingredients must be dry and powdered to a reasonably fine grain, but need not be reduced to the fineness of flour. All mixing is done by rocking on paper or by careful use of wooden spoon held at arm's length. No rubbing can be permitted, otherwise spontaneous combustion might take place. Don't experiment with the addition of any other ingredients. To do so is to invite disaster.

After the ingredients have been intimately mixed they are dropped into a cylinder of cardboard, or paper tube. To make the cylinders, roll a single overlapping turn of waxed paper over a dowel about half an inch in diameter. Apply mucilage to one side of a sheet of writing paper. Roll on the mucilage coated paper and slide the tube so formed off the dowel. Pull out the waxed paper and set the tube aside to dry. Cut into desired lengths, allowing enough at the bottom to fold over.

If colored fires are to be held in the hand an eight inch section of dowel

should be left at the bottom of each tube. The paper then is rolled around the dowel directly, omitting the waxed paper.

Do not fill with chemicals until the paper tube is perfectly dry. After dropping in a teaspoonful at a time the material should be tamped into the tube lightly with the wooden dowel.

Serpent's Eggs

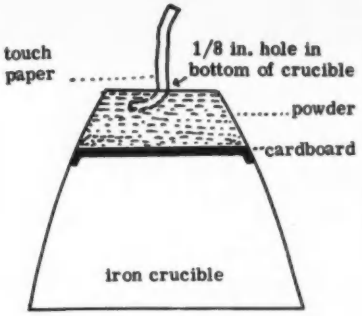
Thoroughly mix together 3 parts potassium nitrate, 5 parts sugar, and 5 parts potassium bichromate. Form a paste with alcohol and mold into pellets. When dry, ignite with touch paper. A bulky snake-like ash is formed.

Flower Pot

Mix together 1 part each of powdered magnesium, powdered iron, charcoal, and sulfur; ½ part of powdered zinc, and 2 parts of potassium nitrate. Now obtain a small iron crucible and drill a small hole in the bottom of it. Insert a strip of touch paper through the hole, extending about ½ inch into the crucible. This will serve as a fuse. Holding your finger over the hole, pour in the mixed powders, until the crucible is about ¼ full. Then wedge the mixture in with a piece of cardboard and invert the crucible (see diagram). Ignite the touch paper, step back and witness a brilliant display. The flower pot must be ignited outside, as the flying sparks will attain considerable height.

Sparklers, I.

A mixture of 20 parts potassium nitrate, 6 parts sulfur and one part charcoal is blended together with gum arabic solution to form a thick paste. Obtain several lengths of thin wire



Flower Pot - cross sectional view

strips and dip them into the paste. When dry, ignite with a match.

Sparklers, II.

Showers of sparks come from the ends of these wands. This is a good wand for a magic fairy, and may be used for many other effects.

Powdered sulfur	2 oz.
Potassium Nitrate powdered	10 oz.
Powdered charcoal	3 oz.
Iron filings	4 oz.
Powdered aluminum	1 oz.

If chemicals are not in powdered form, each must be powdered separately. Make sure that you use a clean mortar when handling the potassium nitrate. Powder only a small quantity at a time. Do not mix in the mortar, instead, pile all of the ingredients on separate sheets of paper, then combine them by using a wooden spatula or by merely rolling the paper back and forth.

Add the mixture to alcoholic shellac until the liquid becomes like a thick sirup. Cut 18 inch lengths of soft iron wire, about No. 18 gauge, fashion hook at one end of wire, pour shellac and chemical mixture into a tall cylinder and dip in the wires one at a

time. Hang by the hook to dry. Repeat dipping until the coating is about the thickness of a lead pencil. These will take quite a bit of heat to ignite them, but one can be started easily from the burning tip of another. Sparks are harmless, but wire is very hot, so avoid burns.

All-Star Sparkling Fire

Mix together 1 part each of powdered magnesium, powdered iron, charcoal, sulfur, powdered zinc, antimony sulfide, lycopodium powder, cloves, ginger, cinnamon, sugar, and 3 parts potassium nitrate. Ignite outside with touch paper.

Guncotton

For tossing flame into the air and for the production of a variety of explosive effects, few things are as satisfactory as gun cotton.

Mix 20 parts by volume of concentrated sulfuric acid with 25 parts of concentrated nitric acid. Mix slowly and stir with a glass rod. Make sure that the container in which the solutions are mixed is able to withstand the heat and by all means perform the experiment in the laboratory sink just in case the receptacle breaks.

Immerse ordinary absorbent cotton in the mixture after it has cooled to room temperature. Let it soak for five minutes. Remove it with a glass rod and wash it in a large quantity of running water until all of the acid has been removed. Let it dry thoroughly, at room temperature.

When an open wad of the cotton is ignited it goes off with a rapid flash and the evolution of a large quantity of gas. If a wad is tightly rolled into a sheet of paper it explodes as well. The tighter the packing the greater the noise.

Colorful Flames

Camp fires will burn brighter in summer and log fires will be more colorful in winter if you throw on the fire lumps of sawdust which have been soaked in chemical solutions and then allowed to dry. The flames will blaze yellow, red, green or blue, depending upon the chemicals used.

First, determine the amount of water which must be added to the sawdust to get the proper consistency. Fill a drinking glas to the brim with water and gradually add this water to a heaping cupful of sawdust, kneading all the time, until it forms a mass of puttylike consistency which will keep its shape when squeezed together.

By measuring the amount of water left in the glass, you can figure how much water was taken up by the sawdust. This tells you how much you need in making your chemical "logs." Discard this batch of sawdust.

If you needed half a glassful of water for your test mixture, add a teaspoonful of potassium nitrate to half a glassful of water and stir until completely dissolved. Use this solution to moisten a cupful of fresh sawdust.

Making the Log

Press the moist sawdust together and either shape it into a cone, roll into a log or mold into a thin paper tube made from a single sheet of writing paper. Set the molded product aside to dry thoroughly—do not attempt to make it dry faster with artificial heat. Within a few days your sawdust block will be ready for use. When you light it, it will produce a yellowish-white flame.

If, instead of using a teaspoonful

of potassium nitrate in the water, you substitute half a teaspoonful of strontium nitrate, the flame will be bright red. If a half teaspoonful of barium nitrate is used instead, you will get a brilliant green flame. The addition of a small quantity of copper sulfate to the teaspoonful of potassium nitrate will change the yellowish white flame to blue.

A most colorful log for use in a small fireplace or to add a festive spirit to your campfire can be made by mixing batches of sawdust as described above. Take a pinch from one of the batches and against this press a small quantity from a second batch of moistened sawdust. By adding bits of sawdust moistened with the various salt solutions, you can form a log which will produce different colored flames.

Short sections from such a log may be used as colored flares. Place them on the ground before lighting.

Brilliant Colored Smoke

Colored smokes — bright-hued greens, yellows, reds, blues, and other colors — were used extensively by American fighting men during the war for many kinds of signaling.

Only smokes of definite and unmistakable colors were used, except in certain cases, to avoid confusion with gray, white or black smokes produced on the battlefield by high explosives, by screening smokes, or by burning equipment or structures.

Signal smokes, the Technical Command said, can be made by dispersion of finely powdered materials, by chemical reactions which produce colored smokes, or by volatilizing colored materials. Only the latter method has been found feasible for smoke of high volume and high color intensity.

Organic dyes and dye intermediates have been found to be the only practicable colored materials suitable. Except for black smoke, all the colored smoke signals are based upon volatilization of dyes and dye intermediates. The dyes found feasible are mainly anthraquinone derivatives.

The colored smoke compositions are essentially pyrotechnic mixtures of a fuel, consisting of a combustible material and an oxidizing agent, a dye, and sometimes a cooling agent.

The heat produced by the reaction of the fuel constituents volatilizes the dye which condenses outside the munition to form a smoke. A cooling agent which may be added serves to regulate the rate of the burning of the fuel and lower the temperature of combustion so as to prevent excessive decomposition of the dye, evidenced either by decolorization or strong flaming.

The only oxidizing agent that was satisfactory in the fuel mixture was potassium chlorate, with sugar one of the best combustible materials. The best cooling agents were found to be either sodium or potassium bicarbonate.

In investigations of dyes, the anthraquinone dyes were found superior to all others in producing smoke clouds. The azo derivatives furnished very few suitable dyes, and in no case were these superior to the anthraquinone dyes. Their defects are their tendency to flame and to produce transparent smokes. Among the azine types, rosindone and its derivatives gave excellent bright smoke clouds without any flaming. Their color range, however, is limited to red and orange.

In Grand-pa's Day

Scientific amusements are by no means new, as is shown by the following selections from an old American public school text book, Peterson's Familiar Science, adapted from an earlier English work but first published for Americans in Philadelphia in 1851. The second edition of this lively book contains an even livlier section, "Scientific Amusements for Young People," by John Henry Pepper, from which these directions and illustrations are taken.

Star-Like Crystals

➤ Pour three ounces of diluted nitric acid into a glass vessel, and add to it gradually two ounces of bismuth broken by a hammer into small pieces. The metal will be attacked with great energy, and nitrate of bismuth will be formed. Crystallize the solution by a gentle heat, and preserve the crystals, which possess great beauty, under a glass.

Groups of Crystals

➤ Dissolve in seven different tumblers, each containing warm water, half-ounces of the sulphate of iron, copper, zinc, soda, alumina, magnesia and potash. Pour them all, when completely dissolved, into a large evaporating-dish of Wedgwood ware, and stir the whole with a glass rod; set the dish in a warm place, where it cannot be affected by the dust, and where it may not be agitated. When the necessary evaporation has taken place, the whole will shoot out into crystals. These will be interspersed in small groups and single crystals among each other. Their color and peculiar form of crystallization will distinguish each crystal separately, and the whole together, remaining in the respective places where they were deposited, will display a very curious and beautiful appearance. Preserve it carefully from dust.

Crystals of Alum

➤ Dissolve a pound and a half of alum in a quart of boiling water, and suspend in it a piece of coke; set it aside to cool, and a beautiful crystallization, resembling a mineralogical specimen will be obtained.

Metallic Crystallization

➤ Melt a ladleful of bismuth, and let it cool gradually till a thin crust has formed on its surface; then, by means of a pointed iron, make two small apertures through the crust; quickly pour out by one of the openings the fluid portion, as carefully and with as little motion of the mass as possible, whilst the air enters at the other. On removing the upper crust by means of a chisel, when the vessel has become cold, a cup-shaped concavity will appear, studded with very brilliant crystals, more or less regular, according to the quantity of bismuth employed, the tranquility and slowness with which it cooled, and the dexterity with which the fluid portion, at the moment it began to harden, was decanted from the crystallized part. The same effect may be produced by fusing the substance in a small crucible which has a hole at its bottom, lightly closed by an iron rod or stopper, which is to be drawn out when the mass begins to congeal; by

this means the superior portion, which is fluid, is made to run off, and a cake studded over with crystals is obtained.

Blue Vitriol

➤ Boil a few copper filings in concentrated sulphuric acid, to which a small portion of nitric acid has been added, and, when the copper is dissolved, dilute the mixture with a little water, and then leave it where it can cool gradually. If the mixture be then suffered to remain a few hours undisturbed, beautiful crystals of blue vitriol will be found at the bottom of the vessel, as hard as some minerals.

Oxy-chloride of Lead

➤ Melt in the bowl of a tobacco-pipe, or in a small crucible, a mixture of an ounce of litharge of lead, and a drachm of pulverized muriate of ammonia: when well incorporated by exposure to a red heat, pour it into a metallic cup, and allow it to cool: the result will be oxy-chloride of lead of a bright yellow color, which, when broken, will present a most beautiful crystalline appearance.

Glauber Salts

➤ On a solution of common soda pour, by small quantities at a time, diluted sulphuric acid, until the effervescence ceases; by gently evaporating the solution in a saucer near a fire, crystals of sulphate of soda (Glauber Salts) will be obtained.

Common Salt

➤ Take some muriatic acid, and mix it with thrice its bulk of water, adding thereto as much soda as it will dissolve; by slowly evaporating the solution before the fire, muriate of soda (common table salt) will be obtained.

To Make Large Crystals

➤ The salt to be crystallized is to be dissolved in water, and evaporated to such a consistency that it shall crystallize on cooling. Set it by, and when quite cold pour the liquid part from the mass of crystals at the bottom, and put it into a flat-bottomed vessel. Solitary crystals will form at some distance from each other, and gradually increase in size. Pick out the most regular, put them into another flat-bottomed vessel, a little apart from each other, and pour over them a quantity of fresh solution of the salt, evaporated till it crystallizes on cooling. Alter the position of every crystal once at least every day, with a glass rod, that all the faces may be alternately exposed to the action of the liquid; for the face on which the crystal rests never receives any increase. By this process the crystals will gradually augment in size. When they have acquired such a magnitude that their forms can easily be distinguished, the most regular are to be chosen, or those which have the exact shape which you wish to obtain. Each of them should be put separately into a vessel filled with a portion of the same liquid, and turned by the glass rod several times a day, and by this treatment you may obtain them almost of any size desired. Whenever it is observed that the angles and edges of the crystals become blunted, the liquid must immediately be poured off, and fresh liquid put in its place; otherwise the crystals will be infallibly destroyed.

Lead Tree

➤ Dissolve two drachms of acetate of lead in a quart of water, and set it aside for a day or two, decant the clear solution into a large phial, and in the centre suspend a piece of zinc, by means of a silk thread fixed to the cork. If the whole be left undisturbed, the lead will arrange itself around the zinc in beautiful metallic plates resembling a shrub.

Silver Tree

➤ Let six drachms of a saturated solution of pure silver in nitric acid, and four drachms of a similar solution of mercury in the same acid, be diluted with five ounces of distilled water, and poured into a small decanter or glass phial; then compose an amalgam, by mixing one part of finely-divided silver with seven parts of mercury, and place a small lump of it at the bottom of the bottle, which must be kept quite still. In a short time the surface of the amalgam will be covered with minute filiaments of silver, and after standing about forty-eight hours, the solution will deposit all its silver, in the form of brilliant, arborescent crystals, springing like a glittering shrub from the bottom of the vessel.

Prince Rupert's Drops

➤ Glass is an extremely bad conductor of heat, and the small glass toys, called Prince Rupert's drops, show this very clearly. They are made by dropping a small quantity of glass, while almost in a liquid state, into water, by which means a globule with a spiral tail is instantly formed; the outside of the globule cools and solidifies the instant it comes into contact with the water, before the inner part changes, and this, as it gradually hardens, would contract, were it not retained and kept in its form by its adherence to the outer crust. If the tail is broken off, or any other injury done to the globule, it will burst with a slight noise and fall to pieces.

Experiments With Hydrogen

➤ When a gas-jar is filled with hydrogen, it may be lifted carefully from the pneumatic trough without fear of any gas escaping and placed on a stand sufficiently high to admit of the hand being inserted into the jar; if one of the squeaking toys be first worked in the air and then in the jar of hydrogen, the effect is very laughable, as the sound becomes so shrill, in consequence of the levity of the gas. A bell sounded in air and afterward in hydrogen is also an amusing experiment.

Hydrogen Organ

➤ Take the generating hydrogen bottle, and fit a long jet with a small orifice; if the hydrogen is set on fire, and a tube placed over it at a certain place, the hydrogen flame begins to flicker and emit a sharp sound, which is varied according to the length and diameter of the glass tubes. Sometimes many tubes may be tried before the sound can be obtained.

Take Care with Hydrogen

➤ If it is desired to see the hydrogen burn from the end of the jet, it should be turned up straight, and before applying flame the first portion of the gas must be allowed to escape, or else the air already in the bottle mixes with the hydrogen and forms an explosive mixture, and, if this is fired, the cork and pipe are blown to the ceiling, whilst the bottle is frequently broken and the acid spilled about. A case occurred where some boys, making hydrogen in their bedroom in an

ink-bottle, with a tobacco-pipe stem for a jet, incautiously applied the flame, when the whole exploded, and one of the poor boys lost his eyesight.

Sympathetic Inks

➤ All writings or drawings executed with sympathetic inks are illegible until, by the action of heat or some chemical agents upon a peculiar acid or substance which forms the basis of the ink, a change is effected, and a color produced from that which was before colorless.

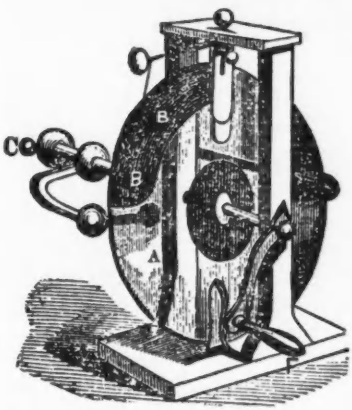
1. Write with a weak solution of sulphate of iron, and it will be invisible; when dry, wash it over with a solution of prussiate of potash, and the writing will be restored, and turned to a beautiful blue.

2. Write with some of the above solution, and it will, as before stated, become invisible, but if a brush which has been dipped in a decoction of oak-bark, or tincture of galls, be slightly passed over it, it will turn black.

3. Write with the nitro-muriate of gold, and brush the letters over with muriate of tin in a diluted state. The writing, before invisible, will then appear of an exquisitely beautiful purple color.

4. The most curious of all kinds of sympathetic ink is that procured from cobalt. It is a very singular phenomenon, peculiar to this ink, that the characters of figures traced out with it may be made to appear and disappear at pleasure; all other kinds of sympathetic ink are at first invisible, until some fluid has been applied to cause their reappearance, but when once they are developed they remain permanent. To make this ink, take zaffre, and dissolve it in nitro-muriatic acid, until the acid extracts from it the metallic part, or cobalt, which communicates to the zaffre its blue color; then dilute the solution, which is very acrid, with common water. If you write with this preparation, the characters will be invisible; but when exposed to a moderate degree of heat, they will become green, and on the paper cooling again they will vanish. However, if the paper is overheated the writing will not disappear.

5. Write with a diluted solution of muriate of copper, and the writing will be invisible, when dry; but on being held to the fire it will be of a yellowish-green color.



The Electrical Machine

➤ Formerly the electrical machine was made in the form of a cylinder, but now it consists of a plate, A, as seen in the engraving. The plate is turned by the handle F through the rubber B B, which diffuses the excitement over the glass. The points or balls at each side of the plate carry off a constant stream of positive electricity to the prime conductor C. Negative electricity is generated by insulating the conductor to which the cushion is attached, and containing the prime conductor, into the ground, so as to carry off the fluid collected from the plate.

How to Draw Sparks

➤ If the person who works the machine be supported on a stool having glass legs and connected with the conductor by means of a glass rod, the electricity will pass from the conductor to him, and, as it cannot get away, owing to the glass on which he stands being a non-conductor, any person on touching him can draw the electricity from him, which will exhibit itself in small sparks as it passes to the person who touches him. If touched on the nose, sparks of fire will issue from it.

The Electrical Kiss

➤ This amusing experiment is performed by means of the electrical stool. Let any lady challenge a gentleman not acquainted with the experiment to favor her with a salute. The lady thereupon mounts the glass stool, and takes hold of a chain connected with the prime conductor. The machine being then put in motion, the gentleman approaches the lady, and immediately he attempts to imprint the seal of soft affection upon her coral lips, a spark will fly in his face, which generally deters him from his rash and wicked intention.

Ringing Bells

➤ Bells may be made to ring by electricity in the following manner.

Let three small bells be suspended from a brass wire, D D, and supported by a glass pillar A, passing through bell B to bell E. The electrical apparatus being attached to the knob E, the electricity passes down the wires D D to the bells, which are then positively electrified and attract the clappers C C, that are negatively so, in consequence of being insulated by the silken strings, which are not conductors. The bells therefore attract the clappers till they are charged, when they strike against the center bell to discharge themselves,

and thus a peal is rung on the bells until the electricity is driven off.

The Electrified Wig

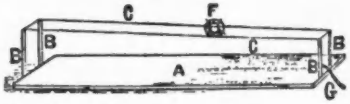
➤ WHILE a person is on the electrical stool, if he be charged with much electricity,

"Each hair will stand on end,
Like quills upon the fretful
porcupine."

A wooden head — not your own, but a real wooden head, with a wig of streaming hair, and a handsome face to correspond — may be made in the following form, with a wire in the neck to support it by, and fixed in the conductor of an electrical machine. When this is put in motion, the hair will rise up as in the figure, to astonish even those who are seldom astonished by or deterred from any thing.

Working-Power

➤ THIS may be shown in a variety of ways. The subjoined machine will exhibit the principle upon which many ingenious toys may be made by the young philosopher. In the figure, A is a wooden board or stand, B B B B, four pillars having fine wires, C C, stretched above. On these rest the rotatory wire or wheel F, having its points turned the reverse ways. By means of a chain attached to the conductor, and to the instrument at B, the electricity passes over the pillar B, up the wire C, into the wheel, and off at the points, which causes it to be turned round on an inclined plane till it reaches the top.

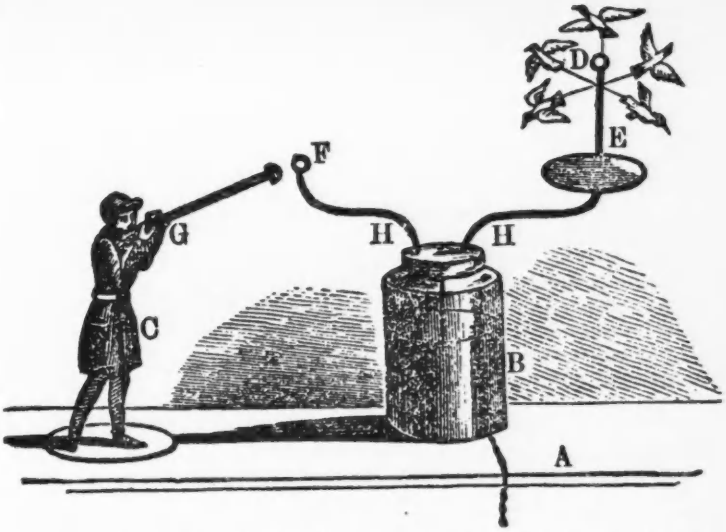


Leyden Jar

➤ A MOST useful piece of apparatus is called the Leyden jar. It is employed for the purpose of obtaining a quantity of electricity, which may be applied to any substance. It consists of a glass jar, coated both inside and without, four-fifths of the way up, with tinfoil. A knob rises through a wooden top communicating with the inside of the jar. When it is wished to charge the jar, this knob is applied to the prime conductor of the electrical machine when in action, and, a quantity of electricity being given off, the jar will remain charged with it till a connection is made by some good conductor of electricity between the knob and the outside tinfoil. A piece of brass chain must hang from the stem that carries the knob and connect it with the interior of the jar.

The Sportsman

➤ THIS apparatus is capable of affording much amusement. A is a stand

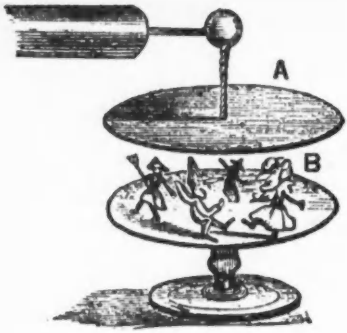


of wood; B is a common Leyden jar, out of which proceed the wires H H, one terminating in the ball F, the other in the ball D, to which are attached a number of pith birds by silken strings; E is a shelf for the birds to rest upon; C is the sportsman; G his gun.

To put this operation in motion, Leyden jar is to be charged with electricity by affixing a chain to the bottom part of it, and connecting it with an electrical machine in the usual manner, or by applying it to a prime conductor, when the birds will fly off the knob to which they are fixed, in consequence of their being repelled. If the sportsman and gun be then turned so that the end of his gun shall touch the knob F, an electric spark will pass from one to the other, a report will be heard, and the birds will fall down as if shot, in consequence of the electricity having been taken from the Leyden jar. There should be a communication between the sportsman and the jar, formed of tinfoil, or some metal, as shown by the dotted line on the stand.

Dancing Dolls

➤ Get two round pieces of wood, A, B, and coat them with tinfoil; or two pieces of metal plate; attach one of them to the prime conductor by a chain, and let it hang about two or three inches from the knob. Place some pith-balls upon the bottom piece of wood, B, and bring it under the other. Immediately this is done, and the upper piece is charged by electricity from the machine, the pith-balls will jump up and down, and from one to the other, with great rapidity. If some of the pith be formed into little figures, they will also



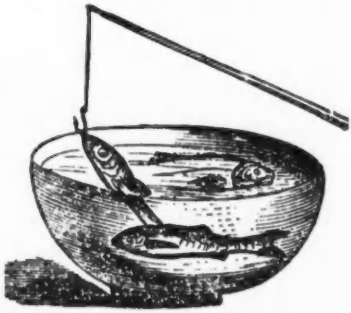
dance and leap about in the most grotesque manner. The same may be made to dance by merely holding the inside of a dry glass tumbler to the

prime conductor for a few minutes, while the machine is in action, and then whelm it over them, when they will jump about, to the no small astonishment of the spectators, as the cause of their motions is not quite so apparent.

Magnetism Experiments

Magnetic Swan

➤ Form a swan of cork, and place within its beak a little bit of steel strongly magnetized, then cover it with a thin coating of white wax, and, to render the image more complete, glass beads may be put into its head to represent the eyes. The swan being thus made, you must provide it with a lake to swim in. A basin of water may supply this, and when your lake is ready and the swan placed in it, the next object is to make it swim about. This you may easily accomplish by holding in your hand a magnetic bar, on which the north and south poles are marked. Show the north pole of the wand to the swan, and the little creature will immediately follow it, moving very gently over the water; you may thus lead it about; and when you wish it to retire, present the south pole of the



wand to it, and, like a good, obedient bird, it will readily recede and turn back.

If you wish to make a magnetic wand, you may do so by procuring a hollow cane eight or nine inches in length and half an inch thick, and a small steel bar well magnetized. Put this bar in the cane, and close it at both ends by screwing on small ivory tops differing in shape, or having some marks by which you may in an instant recognize the north and south ends of the rod. With this wand you may direct the course of any floating figure you may choose to fashion.

Magnetic Fish

➤ Fish are to be purchased at the toy-shops, by which the young *magnétique* may perform this experiment: they are made hollow, and will float on the water. In the mouth of each should be inserted a piece of magnetic wire. The angling-rod is like any other rod, and has a silken thread for a line, and an iron hook, also strongly magnetized. To catch the fish, it is only necessary to put the hook in contact with the noses of the fish, and they will be taken, without any of the baits mentioned in the "Young Angler."

➤ Flying machine *offered without further description of its operation. It is labelled, somewhat needlessly for modern readers: "theoretical."*

A Word About Flares and Bangs

➤ PLAYING with fire provides a double thrill, combining truly beautiful effects with a spine-tingling sense of imminent danger. The competent young chemist will not handle dangerous reactions carelessly. He will understand what the dangers are, and take care not to let accidents happen. He will keep his face and hands away from burning and explosive mixtures, and check apparatus against dangerous gas pressures. He will observe to the letter such cautions as "grind separately" in directions for making gunpowder.

Ours is a highly flammable world, and experience with fire is an inescapable part of our training for living. The young child approaches with terror his first attempts at scratching matches and lighting the gas stove. And rightly so, for both are experiments with explosive chemicals. But the wise parent will train him to perform these experiments safely.

In the chemistry laboratory, the student meets many unfamiliar substances. Some of them are explosive in the same way that the match-head is explosive, and are set off by friction. Others explode when mixed with air and ignited by flame, as does the gas over the gas-burner. These explosions are examples of quick burning. In the open air this is over in a moment, and the products of the reaction diffuse freely into the air.

If a quick-burning reaction takes place in a closed space, and produces gases which are quickly expanded by the heat generated, the container may break and injure anyone within range of the flying glass or metal. Flame striking back into a hydrogen generator produces this kind of explosion.

Nitrogen compounds enter into the class of unstable materials known as "high explosives." Energy is absorbed when these materials are formed, and hangs ready to let go when their equilibrium is upset by a detonating charge or an accidental jostle. High explosives are notable for the shattering effect all around them when they go off. The rock underneath is broken and a hole scooped out of the earth, even though the reaction was set off in the open air. This shattering quality is called *brisance*. Nitroglycerine, TNT and PETN are examples of brisant explosives.

Ammonium nitrate, although it has twice in recent years triggered disastrous explosions, is not an explosive of this class. Alone, it is as inert as table salt. Contaminated with organic matter, which can furnish oxygen, hydrogen and carbon, reactions take place whose products are all gaseous. Sudden expansion of hot gases again accounts for most of the damage.

The flares and bangs provided by the recipes in this book result from the relatively harmless kind of explosions. The chemist, however, must be careful, watch gas pressure in his apparatus and remember that expanding hot gases move very fast. He will work carefully and neatly, using small quantities of materials, adequate protection and tools, and a never-failing respect for the forces he is putting in motion.

The Chemical History of a Candle

by Michael Faraday

Edited by William Crookes

➤ Now, as to the light of the candle — We will light one or two, and set them at work in the performance of their proper functions. You observe a candle as a very different thing from a lamp. With a lamp you take a little oil, fill your vessel, put in a little moss or some cotton prepared by artificial means, and then light the top of the wick. When the flame runs down the cotton to the oil, it gets extinguished, but it goes on burning in the part above. Now, I have no doubt you will ask, how is it that the oil which will not burn of itself, gets up to the top of the cotton, where it will burn? We shall presently examine that, but there is a much more wonderful thing about the burning of a candle than this. You have here a solid substance with no vessel to contain it; and how is it that this solid substance can get up to the place where the flame is? How is it that this solid gets there, it not being a fluid? or, when it is made a fluid, then how is it that it keeps together? This is a wonderful thing about a candle.

We have here a good deal of wind, which will help us in some of our illustrations, but tease us in others; for the sake, therefore, of a little regularity, and to simplify the matter, I shall make a quiet flame—for who can study a subject when there are difficulties in the way not belonging to it? Here is a clever invention of some costermonger or a street stander in the market-place for the shading of their candles on Saturday nights, when they are selling their greens, or potatoes, or fish. I have very often admired it. They put a lamp-glass round the candle, supported on a kind of gallery, which clasps it, and it can be slipped up and down as required. By the use of this lamp-glass, employed in the same way, you have a steady flame, which you can look at, and carefully examine, as I hope you will do, at home.

You see, then, in the first instance, that a beautiful cup is formed. As the air comes to the candle it moves upwards by the force of the current which the heat of the candle produces, and it so cools all the sides of the wax, tallow, or fuel, as to keep the edge much cooler than the part within; the part within melts by the flame that runs down the wick as far as it can go before it is extinguished, but the part on the outside does not melt. If I made a current in one direction, my cup would be lopsided, and the fluid would consequently run over — for the same force of gravity which holds worlds together holds this fluid in a horizontal position, and if the cup be not horizontal, of course the fluid will run away in guttering. You see, therefore, that the cup is formed by this beautifully regular ascending current of air playing upon all sides, which keeps the exterior of the candles cool. No fuel would serve for a candle which has not the property of giving this cup, except such fuel as the Irish bogwood, where the material itself

is like a sponge, and holds its own fuel.

You see now why you would have had such a bad result, if you were to burn these beautiful candles that I have shown you, which are irregular, intermittent in their shape, and cannot therefore have that nicely-formed edge to the cup which is the great beauty in a candle. I hope you will now see that the perfection of a process — that is, its utility — is the better point of beauty about it. It is not the best looking thing, but the best acting thing, which is the most advantageous to us. This good-looking candle is a bad burning one. There will be a guttering round about it because of the irregularity of the stream of air and the badness of the cup which is formed thereby. You may see some pretty examples (and I trust you will notice these instances) of the action of the ascending current when you have a little gutter run down the side of a candle, making it thicker there than it is elsewhere. As the candle goes on burning, that keeps its place and forms a little pillar sticking up by the side, because, as it rises higher above the rest of the wax or fuel, the air gets better round it, and it is more cooled and better able to resist the action of the heat at a little distance. Now, the greatest mistakes and faults with regard to candles, as in many other things, often bring with them instruction which we should not receive if they had not occurred. We come here to be philosophers; and I hope you will always remember that whenever a result happens, especially if it be new, you should say, "What is the cause? Why does it occur?" and you will in the course of time find out the reason.

Then, there is another point about these candles which will answer a question — that is, as to the way in which this fluid gets out of the cup, up the wick, and into the place of combustion. You know that the flames on these burning wicks in candles made of beeswax, stearin, or spermaceti, do not run down to the wax or other matter, and melt it all away, but keep to their own right place. They are fenced off from the fluid below, and do not encroach on the cup at the sides. I cannot imagine a more beautiful example than the condition of adjustment under which a candle makes one part subserve to the other to the very end of its action. A combustible thing like that burning away gradually, never being intruded upon by the flame, is a very beautiful sight; especially when you come to learn what a vigorous thing flame is — what power it has of destroying the wax itself when it gets hold of it, and of disturbing its proper form if it comes only too near.

But how does the flame get hold of the fuel? There is a beautiful point about that — *capillary attraction*. "Capillary attraction!" you say — "the attraction of hairs." Well, never mind the name: it was given in old times, before we had a good understanding of what the real power was. It is by what is called capillary attraction that the fuel is conveyed to the part where combustion goes on, and is deposited there, not in a careless way, but very beautifully in the very midst of the centre of action which takes place around it . . .

Now, the only reason why the

candle does not burn all down the side of the wick is, that the melted tallow extinguishes the flame. You know that a candle if turned upside down, so as to allow the fuel to run upon the wick, will be put out. The reason is, that the flame has not had time to make the fuel hot enough to burn, as it does above, where it is carried in small quantities into the wick, and has all the effect of the heat exercised upon it.

There is another condition which you must learn as regards the candle, without which you would not be able fully to understand the philosophy of it, and that is the vaporous condition of the fuel. In order that you may understand that, let me show you a very pretty, but very common-place experiment. If you blow a candle out cleverly, you will see the vapour rise from it. You have, I know, often smelt the vapour of a blown out candle — and a very bad smell it is: but if you blow it out cleverly, you will be able to see pretty well the vapour into which this solid matter is transformed. I will blow out one of these candles in such a way as not to disturb the air around it, by the continuing action of my breath; and now, if I hold a lighted taper two or three inches from the wick, you will observe a train of fire going through the air till it reaches the candle. I am obliged to be quick and ready, because, if I allow the vapour time to cool, it becomes condensed into a liquid or solid, or the stream of combustible matter gets disturbed.

Now, as to the shape or form of the flame. It concerns us much to know about the condition which the matter of the candle finally assumes at the top of the wick — where you have such beauty and brightness as nothing but combustion of flame can produce. You have the glittering beauty of gold and silver, and the still higher lustre of jewels, like the ruby and diamond; but none of these rival the brillancy and beauty of flame. What diamond can shine like flame? It owes its lustre at night-time to the very flame shining upon it. The flame shines in darkness, but the light which the diamond has is as nothing until the flame shines upon it, when it is brilliant again. The candle alone shines by itself, and for itself, or for those who have arranged the materials. Now, let us look a little at the form of the flame as you see it under the glass shade. It is steady and equal; and its general form is that which is represented in the diagram, varying with atmospheric disturbances, and also varying according to the size of the candle. It is a bright oblong — brighter at the top than towards the bottom — with the wick in the middle, and besides the wick in the middle, certain darker parts towards the bottom, where the ignition is not so perfect as in the part above.

I have a drawing here — of the flame of a candle. Here is the little flame, and here is represented what is true — a certain quantity of matter rising about it which you do not see, and which, if you are not familiar with the subject, you will not know of. Here are represented the parts of the surrounding atmosphere that are very essential to the flame, and that are always present with it. There is a current formed, which draws the flame out — for the flame which you see is really drawn out by the cur-

rent and drawn upward to a great height . . .

You may see this by taking a lighted candle, and putting it in the sun so as to get its shadow thrown on a piece of paper. How remarkable it is that that thing which is light enough to produce shadows of other objects, can be made to throw its own shadow on a piece of white paper or card, so that you can actually see streaming round the flame something which is not part of the flame, but is ascending and drawing the flame upward: — You observe the shadow of the candle and of the wick; then there is a darkish part, and then a part which is more distinct. Curiously enough, however, what we see in the shadow as the darkest part of the flame is, in reality, the brightest part; and here you see streaming upwards the ascending current of hot air, which draws out the flame, supplies it with air, and cools the sides of the cup of melted fuel . . .

And now, I have to ask your attention to the means by which we are enabled to ascertain what happens in any particular part of the flame — why it happens, what it does in happening, and where, after all, the whole candle goes to: because, as you know very well, a candle being brought before us and burned disappears, if burned properly, without the least trace of dirt in the candlestick — and this is a very curious circumstance. In order, then, to examine this candle carefully, I have arranged certain apparatus, the use of which you will see as I go on. Here is a candle: I am about to put the end of this glass tube into the middle of the flame — into that part represented in the diagram as being rather dark, and which you can see at any time, if you will look at a candle carefully, without blowing it about. We will examine this dark part first.

Now, I take this bent glass tube, and introduce one end into that part of the flame, and you see at once that something is coming from the flame, out at the other end of the tube; and if I put a flask there, and leave it for a little while, you will see that something from the middle part of the flame is gradually drawn out, and goes through the tube and into that flask, and there behaves very differently from what it does in the open air. It not only escapes from the end of the tube, but falls down to the bottom of the flask like a heavy substance, as indeed it is. We find that this is the wax of the candle made into a vaporous fluid . . . If you blow out a candle, you perceive a very nasty smell, resulting from the condensation of this vapour . . . I will arrange another tube carefully in the flame, and I should not wonder if we were able, by a little care, to get that vapour to pass through the tube to the other extremity, where we will light it, and obtain absolutely the flame of the candle at a place distant from it. Now, look at that. Is not that a very pretty experiment?

How to Give Your Talk

by Ann Ewing

➤ As a scientist, you will on some occasions want to explain scientific matters to an audience that knows less about them than you do. It would be hard to find a better model for such a talk than Faraday's "Chemical History of a Candle," from which the foregoing extract is taken. For simplicity of expression and infectious enthusiasm, the great experimenter had few equals.

On other occasions, however, you will want to give a paper on your researches before a meeting of your scientific colleagues. As another kind of example, we offer you Mr. O. Vapor, who is pretty sure to be on the program of any scientific meeting you attend.

When his turn comes and his name is called, Mr. Vapor starts up from his seat and as he dashes for the platform, trips over the cord which connects the microphone. This not only makes an awful noise, but requires a minute (which seems like several) to fix. The speaker coughs nervously two or three times, adjusts his tie, and begins:

"The tritor hydrochloride is quite stable."*

Since this startling pronouncement is delivered in an incoherent mumble, a few of the braver souls in the back of the room start squirming and make slight, almost intelligible, motions designed to tell the speaker inaudibly that he cannot be heard. Their efforts, however, are useless, for the speaker has his eyes glued to his paper. He drones on:

"By hydrolysis of dichloromethlyn, one is dealing with a mixture of voul fluorides, which will really reflare fluorine."

At this point he turns to the blackboard to illustrate his next point. Being a very learned man, he has not one but two techniques with which he can now confuse his audience.

The first is to scrawl hastily and illegibly a long equation, mumble something about it, and quickly erase it before the audience has had a chance to see it. The eraser is one which whitens the board, thus making future equations even more illegible.

The other method is to cover most of the blackboard with a long and complicated equation. The speaker then shifts back and forth in front of the board, talking and at the same time erasing and replacing parts of the equation with new symbols, always with his back to the room.

"If you brought them as a function of the distance here, as against energy, you will have the sum of a repulsive term . . . When heated with powder, this gives us the *dinitro bistro*."

To illustrate this last point the thoughtful speaker has made slides. He even has an assistant at the back of the room who knows that at the words "dinitro bistro" the lights

* The quotations used in this article are not imaginary. They must be the way the speaker sounded to the audience, for they are excerpts from a stenotypist's report of an actual chemical conference.

should go out and the first slide should be shown. After some excitement about the location of the switches, the lights do go out and the first slide is on the screen. It is, needless to say, upside down. This is quickly corrected, but it still reads from right to left. . . .

Mr. O. Vapor could have made other, possibly more serious, mistakes but, if you want to avoid pitfalls which this speaker did not, a few suggestions may be helpful.

The two most important things to remember, in making a speech, are that you must know your subject and you must have a strong desire to tell your audience about it.

Since you probably have spent weeks, months or even years in preparation, there is little doubt that you know your subject. But, if you do not have a firm and persistant urge to tell your audience about it, better not make a speech at all.

One of the advantages of knowing your material thoroughly is that you can spend your time looking at the audience. This will not only help you tell whether you are being understood but it will add considerably to the effectiveness of your delivery.

A good method is to pick out one person near the front on the left-hand side of the audience, talk to him for 30 or 40 seconds, then shift your gaze slowly to the rear on the right side, and talk to a person there for half a minute or so. Continuing this procedure, but varying the person, will give each listener in the audience the feeling that you are talking directly to him. It will also help you to make your delivery conversational.

If you know from past experience that your knees will be shaking when you get up in front of all those people, stand erect and act confident, no matter how shaky you feel.

As an aid to seeming confident, it is a good idea to memorize the opening sentence or two of your speech. This will not only give you time to establish your self-confidence but will give you a chance to judge how your voice is carrying. Concise notes on index cards, to remind you of the main points you wish to cover, will carry you through the rest of your talk.

Practice your talk orally, not once but several times, and do so at least twice in front of a mirror. Silly as you may feel talking to a mirror, this practice will keep you from looking silly to your audience.

Remember that before you start your speech you have your listeners with you. They want to hear what you have to tell them — that is why they are there. If you are eager to talk to them and have something to say, there is no reason why your speech should not be a success.

And take the necessary time before the meeting to check the mechanical gadgets that help so much when they are working smoothly but can go so perversely wrong if they are not watched. Have your lantern slides made standard size and see that they fit the lantern. Test whether they will be in focus when shown. Try the size of your writing on the blackboard so that it can be seen from the rear of the room. Learn the idiosyncrasies of your microphone. Then you are ready to get across to your audience the things they came to hear.

How to Press Agent Your Show

by Watson Davis

➤ When the old-fashioned circus used to come to town, one of the most important behind-the-scenes performers was the man who ballyhooed the big top to the public through the newspapers, the billboards and the store show-windows.

He was an advance man, a press agent and a seeker of free publicity, unashamed and unrepentent.

The elephants pranced, the clowns cavorted, the acrobats did their flings, and the daring young man swung on high. But the jovial circus press agent, with plentiful passes sticking out of his pockets, was in the old days no less a part of the show.

All the skills of the old-time press agent are needed for the modern publicity for the things that people want to sell these days, whether they are toothpaste, soap powder, the qualities of would-be statesmen or the Hollywood production that aspires to be the big show of today.

To the newspapers, posters and parades of yesteryear, there have been added radio, television, loudspeakers on trucks, sky writing, prize contests, and even the cultivated word-of-mouth or columnist-bred rumor. These are all forms of publicity — advertising, whether paid or free.

Whether it is a circus, a medicine man selling a nostrum, a department store, or chemical show you are giving at your school, the appeals for attention, prestige and patronage are much the same.

You try to reach as many people as you can — or as many as you wish to interest.

A commercial enterprise puts advertisements in the newspapers, sponsors radio announcements, and tries to get its product written about in the news columns or gossiped about by columnists and commentators.

An entertainment in a school may be publicized by announcements at regular assemblies, notices read by teachers to classes, posters in the hall ways, information chalked on blackboards, mimeographed circulars and even a whispering campaign that capitalizes on human curiosity.

The school newspaper will be used for news stories and advertisements. Tickets will be sold vigorously if there is to be an admission charge. Holding the show in class time, a mild form of bribery to an audience, may be arranged if the teacher or principal can be won over. Even parents may be enticed to come if the publicity is extended outside the school and the students dramatize the show to the folks at home.

If the city newspaper sees a feature story in it, the city editor may assign a reporter and a photographer to cover it. To persuade them, hand-outs (that's technical for an article that is written for publicity purposes) can be prepared and sent to all the newspapers and radio stations. They might start like this:

"A pretty girl will be kissed with shocking results at—"

"Wine will be made out of water on the high school stage tonight—"

You get the idea. Photographers at a rehearsal a week before the show can get pictures that will appear in the papers before the show and thus attract people to it.

Perhaps you can get the show on television. At least, a local radio station can be persuaded to put on a spot announcement — or the young scientists can try to get themselves invited to make guest appearances.

Perhaps *you* can invent a new idea in press agenting your chem show.

Chem Quiz: Old Salts

➤ OLD NAMES for many chemical compounds are still current here and there. The salts whose names are listed in the first column have their formulas listed in the second, in different order. They are identified in the back of the book. Score 4 points for each pair you matched correctly. Yes, there is one duplication.

1. Blue vitriol
2. Calomel
3. Chloride of lime
4. Copperas
5. Cream of Tartar
6. Epsom salts
7. Flowers of zinc
8. Green vitriol
9. Hypo
10. Litharge
11. Liver of sulfur
12. Lunar caustic
13. Microcosmic salt
14. Paris green
15. Powder of succession
16. Prussian blue
17. Red lead
18. Sal ammoniac
19. Sal mirabilis
20. Sal soda
21. Salt of wisdom
22. Saltpeter
23. Slaked lime
24. Sugar of lead
25. White vitriol

(*a*) $HgCl$
(*b*) $3CuOAs_2O_3 \cdot Cu(C_2H_3O_2)_2$
(*c*) ZnO
(*d*) $ZnSO_4 \cdot 7H_2O$
(*e*) $CuSO_4 \cdot 5H_2O$
(*f*) $FeSO_4 \cdot 7H_2O$
(*g*) As_2O_3
(*h*) $Ca(ClO)_2 \cdot 4H_2O$
(*i*) $Ca(OH)_2$
(*j*) $HgNH_2Cl$
(*k*) NH_4Cl
(*l*) $KHC_4H_4O_6$
(*m*) KNO_3
(*n*) K_2S
(*o*) $NaSO_4 \cdot 10H_2O$
(*p*) Na_2CO_3
(*q*) $NaNH_4HPO_4 \cdot 4H_2O$
(*r*) $Na_2S_2O_3 \cdot 5H_2O$
(*s*) $Pb(C_2H_3O_2)_2 \cdot 3H_2O$
(*t*) PbO
(*u*) Pb_3O_4
(*v*) $Fe_4(Fe(CN)_6)_3$
(*w*) $AgNO_3$
(*x*) $MgSO_4 \cdot 7H_2O$

How to Photograph Your Show and Show Your Photographs

by Fremont Davis

▶ Your show or exhibit contains a great deal of material. What you are doing with it is interesting. It wouldn't be a show or an exhibit if it weren't. You want your pictures of it to be, if possible, even more interesting than the show. This takes careful planning.

You will want to get pictures packed with warm human feeling. You accomplish this by shooting for human interest as well as for the record. Close-ups of young people doing things always have interest. Animals are interesting to people. Original, spectacular, action-packed photographs are always at a premium. People will want such pictures, because they constitute the best record of the event that you can make.

You want to get across one idea in each photograph. Keep the picture simple, and use a plain background. Make the lighting of the most important things in the picture contrast in tone value with the rest. This lends emphasis to the most important part.

If you have an art staff available, consult with its members about the composition of your photographs. They can give you tips on how to make the arrangement of objects in your pictures interesting, how to coordinate one object with another, perhaps by emphasizing shadows, and they will remind you that lines dividing a picture into equal portions are to be avoided.

An artist is trained to see good composition. Train yourself to look for it. Get story-telling expressions and action into your pictures. Cultivate a feeling for textures, and emphasize shapes and planes. The light falling on the subject helps you do this. In photography, light not only takes the picture, it also makes the subject interesting.

Light thrown from below gives a weird appearance, suggesting mystery. Light from the back will give large masses of dark objects in the foreground. They will often "make the picture," but be sure to give enough exposure to such shots. When there is not much light on the front areas, faces may not be visible if the exposure is not long enough.

Look out for clarity. If you wish to show faces, get some light on them. To get detail all through the picture, keep the light even over the whole scene. Surfaces reflecting four times as much light as others appear very light in the print compared to more dimly lighted areas.

For reproduction, a picture should have good separation of lights and darks. Good printing of the photograph can help, but this quality should be taken into consideration when the exposure is made.

For most uses, the faces of the people shown are important. The parents and friends of the subject are likely to be interested in the likeness first and the activity later. The school is interested in showing the exhibit or activity as a whole, but the record showing who took part is important here too.

Plan your shooting to cover the uses to be made of the pictures. A comprehensive coverage should include:—

1. Photographs for publicity and advertising the show. Make these as soon as possible and get them out early. Photograph the setting up of exhibits and the rehearsals of plays. Keep the groups small, using just two or three people in a scene. Find interesting material for story-telling photographs. And work with the press and your writers and public relations people.

2. Overall shots of the finished setup. These will show the scope of the undertaking. But even in these, try for detail and a close-up effect, rather than a distant view with a lot of empty foreground.

3. Individual participants. Many will want these, and perhaps you will want to take a picture of every exhibit. A good way to handle such orders is to put them into the hands of one person, who will attend to this detail. Probably a small charge will be made for each print ordered by individuals. Of course, some of these pictures will be good for publicity. The school will often want a file of them for the record, so that the next time the same sort of activity is attempted those taking part will understand better what they are to do. A group photograph of the staff working on the project should be made, if it is not too difficult to arrange.

4. To tell the story. A series of pictures showing a typical participant carrying out each step in the preparation of an exhibit, from laying out the plan and assembling the materials to the completed event, makes an interesting record. If a movie camera is available, such a sequence makes a fine story.

5. News coverage. Be sure to get good pictures, for the papers, of any news events in connection with your show.

Pictures Should Be Seen

If you have pictures, let people see them. Many people will see them if they are published in a newspaper or magazine. A considerable number of interested people will see them if they are posted in public places. If they are used in an exhibit the chances are that they will be seen by a fair number of very appreciative people. Very few people will see them if they are left unmounted in a more or less private place. And no one will see them if no prints are made from your negatives.

For reproduction, make the prints on glossy paper and keep the print snappy in tone value but not too black-and-white. The size should be 5 x 7 inches or larger. The most standard sizes are 8 x 10 or 6 x 8. Interesting pictures with good news stories make acceptable items for use in publications.

Pictures to advertise a show or aid in any other project should be mounted. Good mounting dresses up a picture and puts it to work. Pictures must be placed so that they are easily seen.

The standard size mount for many exhibit purposes is 16 x 20 inches. Boards for the purpose may be purchased in this size. Often the rules for salons of photography require

that prints, whatever their size and shape, must be mounted on these stiff cardboards in such a way that the mounts may be hung vertically.

To mount your picture easily, and get it straight, first place the print on the mount board in the exact position you want it when finished. Make two dots to mark the position along one of the long sides of the print, and one dot on one of the short sides. These three dots determine the position of the print. Pour a small pool of rubber cement onto the back of the print and spread it with the stiff straight edge of a piece of cardboard or wood. Similarly coat the area the print is to cover on the mount .Let the two surfaces dry.

Now put the print down on the mount board at the two dots you made along the long edge. Make sure that the short side comes to its mark. Then roll the print down with a rolling pin, working from the center outward, until it is stuck tight. This makes a very tight bond, which is fairly permanent. Drawings, newspaper clippings, maps, or any other illustrative material for your exhibits may be mounted in the same way.

To get illustrations up to eye level so that they may easily be seen sometimes requires a bit of doing. They must be near eye level if they are 8 x 10 or 11 x 14. The greater the distance from eye level, the larger they should be. Pictures flat on a table are not very effective. They may be used there to explain details of an exhibit, but don't count on them there to attract observers to your exhibit.

Bulletin boards and easels are fine when they are available. Stiff cardboard stands may be made, or sometimes salvaged from discarded window displays from your corner store. Light and portable stands may be designed for the purposes for which you may want to use them, then constructed and added to your lasting equipment.

They may range from a wire between two poles, with prints hung by clothes-pins, to an art-gallery-type of installation with recessed flood-lighting for the exhibits. The kind you build will naturally depend on your resources and the character of the surroundings in which your pictures will be shown. In even the plainest environment it is possible to show them with dignity, good taste and pride of craftsmanship.

Chem Quiz: Can You Tell Them Apart?

➤ Here are a few apparent twins and triplets among chemical names. Do you have trouble distinguishing them? If it is any help, you will find their formulas, as far as possible on the answer page.

Benzene
Benzine
Benzoin
Fluorene
Fluorine
Hexane
Hexene
Hexyne

Ketene
Ketine
Ketone
Luminal
Luminol
Populin
Popular

How to Get Chemical Materials

➤ ALMOST EVERYTHING around the house, in the stores, in the home, in shops or factories and in laboratories can be considered material for experimental use or for demonstration sometime or other.

The common salt in the salt celler on the dinner table is NaCl, while the soda in the kitchen or the medicine cabinet is $NaHCO_3$, sodium bicarbonate, the edible kind, or Na_2CO_3, used for cleaning.

If you want carbon or zinc, they can be salvaged from an old dry-cell battery. Copper is the principal metal of the pennies in your pocket (unless they are the war-time iron ones). Iron, aluminum and other common metals can be found on any scrap heap.

Cerium is in the "flint" of a cigarette lighter, while tungsten can be found in the filament wires of a burned-out electric light bulb.

Plastics in large variety are in everyday use — the difficulty is to tell one from the other. Fibers, synthetic as well as natural, are widely spread about in textiles we use for clothes and in the household. Here again, they are hard to identify, and are often mixed and intermingled.

For reagents, there is acetic acid in the vinegar cruet and citric acid in lemon juice. In smoke-polluted city air there is often too much SO_2, which is the essential of sulfuric acid. Lye in the kitchen (let's hope it is plainly labelled and safely out of reach of childish inquisitive hands) is NaOH, the alkali. Another alkali or base, is available in household ammonia. Red cabbage in the refrigerator is a natural indicator for acids and bases.

For explosives, every household has matches, which go off with a flare when scratched. Cans of highly flammable liquids can be bought for a dime or so at drug and grocery stores, labelled "lighter fluid" or "cleaning fluid."

Several organic solvents are available in quite pure form. Ethyl alcohol is required to be "denatured" with something else, but isopropyl alcohol (which will make you sick if you drink it) comes unmixed. Non-flammable cleaning fluid is carbon tetrachloride. Nail-polish thinner is usually amyl acetate, and the remover, acetone.

One of the purest of chemicals, that would have been a rare wonder in the early days of science, is refined granulated sugar purchasable at about 10 cents a pound. Here is carbohydrate, practically C.P.

Some of the common materials of today, like nylon and rayon, were rarities a few years ago. In the early days of aluminum production, the light metal was actually used for jewelry and small nodules of it were kept as prized specimens in science museums.

The new materials of today, as they come on the chemical scene, have a similar rarity value. There are some materials that, if you can get hold of them, will be striking for experimental or demonstration use. Some of these will be intermediate products or raw materials of relatively common things.

By visiting factories or chemical plants, you can often obtain samples

of such materials, and use them in demonstrations and chemistry shows. Supply houses and dealers have for sale supplies of some unusual materials.

All sorts of minerals, including the ores of rare metals and the sources of other chemical elements, can be obtained from mineral specimen dealers. Supply houses often list in their catalogues specimens and exhibits of chemical interest.

Some suggestions as to where to find such materials are listed under the heading "Free and Low Cost Materials for Science Clubs" in the Sponsor Handbook issued annually by Science Clubs of America, obtainable from Science Service, 1719 N St. N.W., Washington 6, D. C., at $1.00 for individuals (free to *bona fide* Science Club sponsors).

There are many more descriptions in words and pictures available than actual specimens.

One series of experimental kits, including materials, issued by Science Service, the publisher of CHEMISTRY, makes available materials that are not otherwise easily obtained. One of these THINGS of Science kits, as they are called, is issued each month. They may be obtained for a membership at $4.00 a year. Not all the THINGS units are strictly chemical in nature, but most of them contain materials, specimens, descriptions and experiment directions that relate in some way to chemistry.

Some of the THINGS units already issued are still available in limited quantities.

Fibers and textiles are represented in several units. Few people have ever seen a silk cocoon or seen in the form of exhibits the process story of silk. Materials specially imported from Japan, obtained from pre-war parachutes, and developed with the cooperation of leading silk manufacturers are contained in the THINGS Silk Unit (No. 101).

Contrasting with this animal fiber is one of the latest of the synthetic fibers, vinyl resin, the story of which is told in THINGS Unit No. 85. Vinyl resin, made from natural gas or coal, salt, water and air is used industrially for filter cloth because of its chemical resistance. It is also used as sailcloth because it is quick-drying and mildew-resistant. The paper-like tea bags you use are made of a blend of rayon and Vinyon fibers and a sample is included in the kit.

In the THINGS kit on Specialized Textiles (No. 95) there are samples of two textiles that incorporate asbestos, a mineral fiber. One of these is a heavy white fabric that contains 80% asbestos fiber mixed with cotton to give fire resistance. Dish towels of superior quality are made from an 80% cotton- 20% asbestos mixture also sampled in the kit. In this kit also are elastic yarns, cotton, aluminum and nylon wound around cores of rubber. And cotton can be made 70% stronger by mechanical and chemical treatment as demonstrated.

An unusual natural fiber few have recognized, if they have ever seen it, is ramie. The stalk of the plant, intermediate products and, finally, cloth of ramie are included in THINGS unit No. 76.

Nylon is coming into more and more use these days, but in THINGS unit No. 57 there are forms and uses of it that are not often seen. There is

a tough, plastic sheet, as well as nylon thread as it comes from the spinning machine. There are nylon-insulated wires for electrical use, and Army shoelaces that resist damage from mildew and were therefore used for troops that were sent to the tropics.

Bark that can substitute for wool. Cloth-like material made without weaving. A leather substitute that is made of woven plastic. Acetate laminated with fabric, and fabric coated with cellulose. These unusual materials are shown in specimens in the Unusual Fabrics unit, No. 23 THINGS unit.

Did you ever see a cotton boll, the form in which the cotton plant produces the fibers, seed and dried pod? One is included in the Cotton unit of THINGS No. 44.And, more unusual still, are green and brown cotton fibers, naturally-colored. To complete the story there are specimens of the meal made from the cottonseed and the hulls of the seed that go into paper, fertilizer, etc.

Chemicals are widely used for fighting insects and molds that damage crops and materials and make life uncomfortable for man and beast. Samples of the principal insecticides are contained, with experimental hints, in THINGS unit No. 71. Fungicides are the subject of Unit 96.

Lethicin is a material being used in foods and industrial products. It is fully demonstrated in samples and words in THINGS unit 79. Chemical products from corn are contained in Unit 77.

Casein in its various forms can be obtained in THINGS unit 29.

Various natural products of chemical interest are found in THINGS units 43 on spices, 81 on vegetable dyes, 91 on coffee byproducts, 75 on chicle (chewing gum).

Both natural and synthetic materials that are sweet can be sampled in THINGS unit 48.

The metallic elements are represented in THINGS unit 56 on lithium and unit 103 on stainless steel.

Minerals, always a concern of chemistry, are found in unit 78 on petrified wood and unit 17 on mineral optics.

THINGS of science kits are obtainable at a non-profit cost of 50 cents for single units or any three units for $1, postpaid in the U.S.A. by ordering from Science Service, 1719 N St., N.W., Washington 6, D.C.

Each month a new unit is issued and the annual cost for 12 units, many of which in the future will be of chemical interest, is $4, postpaid in U.S.A.

Three more elaborate experimental kits are available from Science Service. One is on Soilless Gardening, containing all the chemicals, materials, etc. needed for experimental hydroponics. Another is on Black Light and Glowing Materials and this contains fluorescent and phosphorescent chemicals, minerals and materials, together with an argon glow lamp, source of ultraviolet light. In a kit on Electricity and Magnetism, there is apparatus for all the basic experiments in this field. These larger Science FUNdamental kits are obtainable at $4.95 each postpaid in U.S.A.

If unsual materials are collected in this way, anyone may have his shelves stocked with interesting substances to excite chemical curiosity.

Chem Quiz Corner

➤ These quizzes, which originally appeared from time to time in Chemistry, are here brought together for the first time, and revised in the light of discoveries since their first appearance. Can you solve them?

The answers will be found in the following section, under the same heading as the quiz and arranged in the same order.

Where Do Elements Get Their Names?

➤ Names of the elements span the time from before the dawn of history to the latest report from the atomic front. They are traditionally dreamed up by the discoverers of the elements. These scientists draw freely on their stocks of "little Latin and less Greek" for the syllables and allusions out of which they compound the names. The first four quizzes are based on the most romantic among these sources of chemical nomenclature.

Among the Immortals

➤ Many of the elements are named for mythological characters, gods or devils of the pagan world. Below is a list of these elements and, in scrambled order, what these beings were noted for. Can you match the character and the element?

1. He had wings on his feet.
2. She was beautiful.
3. He threw the hammer.
4. They played tricks on miners.
5. She fell from heaven.
6. They were big shots.
7. He sowed dragon's teeth.
8. He was a mischievous devil.
9. She planted wheat.
10. He never took a drink.
11. She was a weather prophet.
12. He was all wet.
13. He was the grand-daddy of them all.
14. He caused many spirits to depart.

A. Cadmium
B. Cerium
C. Cobalt
D. Iridium
E. Mercury
F. Neptunium
G. Nickel
H. Palladium
I. Plutonium
J. Tantalum
K. Thorium
L. Titanium
M. Uranium
N. Vanadium

All Colors of the Rainbow

➤ Colors play an important part in chemistry. A number of elements are named for the colors of their salts or their spectrum lines. The names of these elements are called for in this question. Remember to be guided by the meaning of the name, not by the properties of the element. Give yourself a score of 10 for each element guessed correctly.

a. *Chromium* means all colors. What other element has a name of similar meaning?

b. One element whose name means violet.

c. Two elements whose names mean blue.

d. Three elements whose names mean green.

e. One element whose name means yellow.

f. Two elements whose names mean red.

The Geography of the Elements

➤ MANY CHEMICAL ELEMENTS are named for places associated with their discovery. Can you identify the elements asked for in the following questions?

1. What 13 elements were named for America, Cypress, Europe, France, Germany, Magnesia, Poland, Scandinavia, Russia, the Rhine?

2. What four towns have one element each named for them, and what one town has four chemical namesakes.

3. Which three elements were named for people, (*a*) a Swede, (*b*) a Russian, (*c*) a Frenchman and a Pole.

The Et Ceteras

➤ IN THE foregoing we have had Quizzes about elements named for their colors, the homes of their discoverers and the mythological characters who are in evidence in the list. This Quiz rounds up a miscellaneous lot. Can you recognize them?

1. The names of several elements come from traditional names of substances in which they occur. Can you spot the element from (*a*) an astringent medicine, (*b*) a jewel in Aaron's breastplate, (*c*) two from soldering flux, (*d*) flint, (*e*) a heel.

2. What element had its praises sung as a conquering hero?

3. What pairs of elements have names meaning (*a*) lead, (*b*) silver, (*c*) new? (*d*) what two new elements have names suggesting that they are artificial and/or unstable?

4. Four elements have names with rather fanciful associations:

(*a*) This element seems to have reminded its discoverer of a deaf-mute.

(*b*) This element's English name might make you think of Cinderella.

(*c*) This element's name, through an Arabic-Greek pun, came to mean *male*—a regular he-man element.

(*d*) This element might say, "I'm a stranger here myself."

5. Several elements have heavenly associations: (*a*) Earth, sun and moon; (*b*) four planets; (*c*) two asteroids; (*d*) the morning star.

6. Here are ten elements actually named for their properties! (*a*) Four have names derived from the rays they emit; (*b*) two have names meaning heavy; (*c*) two mean hidden; (*d*) two mean stinky.

7. What element has 3 names, given by 3 discoverers, by 3 different methods?

Number, Please?

➤ THIS QUIZ will test your knowledge of the rank of elements by atomic numbers.

Here is the idea: If Ali Baba asked you for a metal whose atomic number is the same as the number in his band of famous thieves, what element would you give him?

Answer: Zirconium, number 40.

Below are some familiar number phrases with number left blank. Fill in the blanks with the correct numbers and identify the corresponding elements from the list, in mixed-up order, on the right.

Give yourself five points for each correct answer. 85 to 100 means you're practically an expert. 70 to 85 means you're average.

Below 70 is an invitation to take a long look at the periodic table, and see for yourself how much chemistry it clarifies for you.

Phrases:

1. ..... Nights in a Barroom.
2. Behind the ..... ball.
3. The ..... dollar question.
4. Heinz ..... varieties.
5. ..... Up.
6. ..... Mule Team Borax.
7. Around the World in ..... Days.
8. ..... and Twenty Blackbirds.
9. Seven Come .....
10. ..... (Titile of a book by Booth Tarkington)
11. The ..... States.
12. The Spirit of .....
13. The Gay .....'s.
14. The Wreck of the Old .....
15. Tea for .....
16. Friday the .....th.
17. A Stitch in time saves .....
18. ..... strikes and you're out.
19. ..... men on a dead man's chest.
20. The Gold Rush of the .....ers.

Elements:

Indium
Lithium
Phosphorus
Chlorine
Mercury
Helium
Calcium
Fluorine
Nitrogen
Neon
Lanthanum
Beryllium
Cadmium
Oxygen
Osmium
Thorium
Gadolinium
Sodium
Aluminum
The next element to be manufactured.

Do You Know the Atom?

➤ WHAT PART, if any, do the following *trons* play in the architecture of the atom? If you can't fit them into their orbits, turn to the answers with a speed not exceeding 186,000 miles per second.

electron
mesotron
thyratron
neutrino
neutron
calutron
positron
natron

Atomic Power

➤ HERE ARE TEN questions about atomic power, its antecedents and consequences. Which are false, which true? The secret is divulged on the answer page.

1. We will soon drive cars powered with atomic energy. True ( ) False ( ).

2. A spy could easily carry the secret of the atomic bomb around in his head. True ( ) False ( ).

2. The United States has the monopoly of uranium. True ( ) False ( ).

4. A chain-reacting pile burns like coal in a furnace. True ( ) False ( ).

5. A slight difference in temperature is sufficient to separate the isotopes of uranium. True ( ) False ( ).

6. The new element plutonium has been found in nature. True ( ) False ( ).

7. Plutonium disintegrates into uranium 235. True ( ) False ( ).

8. As soon as the technical difficulties are overcome, we will have small atomic bombs for blasting. True ( ) False ( ).

9. Radar can protect us against atomic bombs of an enemy. True ( ) False ( ).

10. The energy in a teacup full of water would drive a steamship across the ocean True ( ) False ( ).

What is the State of These Elements?

➤ TOWNS of the U.S.A. have taken their names from many circumstances. Chemists may be surprised to learn that a goodly number of town names are connected with their profession. We have selected a few names of elements. Their chemical states are solid, liquid and gas. Can you name the state (or territory) of the U.S.A. which contains each of these elements —as a town? If not you may address your inquiries to the answer department.

Antimony
Calcium
Carbon
Cobalt
Krypton
Lithium
Mercury
Neon
Platinum
Radium
Vanadium
Zinc

How Long Has This Been Going On?

➤ THE DATES BELOW give the ages of some chemical elements prominent in the news lately, and a few others for good measure. And just to make it easy, we give you the names of the elements, too, but we mixed the order a little. Can you match date and element, and find out how long the world has known that each one exists? One date in the list is correct as it stands. If you just can't wait to find out, turn to the matched lists in the back. But it is more fun to guess.

1735	Aluminum
1755	Bromine
1766	Cerium
1771	Chlorine
1774	Chromium
1789	Curium
1797	Fluorine
1803	Hafnium
1811	Helium
1823	Hydrogen
1827	Iodine
1828	Magnesium
1828	Neon
1868	Platinum
1885	Plutonium
1898	Praseodymium
1898	Radium
1922	Silicon
1942	Thorium
1945	Uranium

When Did We Find Them?

➤ WE HAVE KNOWN some elements a long time, and others we have met only recently. Can you discover when the following discoveries were made?

1. Which seven metals were known to the ancients?
2. What four new metals have been made by transmutation?
3. Which element was discovered during the Dark Ages (and used for Dark Deeds)?
4. What are the first two elements discovered by the human race?

What For?

➤ SOME METALS are used for such specific things that the mention of the use calls the metal at once to mind, as spons make you think of silver. For the following list of uses, what metals do you think of?

electric conections
flashlight powder
cancer treatment
fireworks
thermometers
galvanizing iron
fountain pen points
cigarette lighters
photoelectric cells
neutrons
atomic bombs
bright finishes
money standard
plated food containers
storage batteries
making poisons

In Mother Goose

➤ In youthful spirit we revisited Mother Goose, and found that several of her friends are pretty good chemists. Can you identify these well-known characters? If not, you may hippety-hop to the back of the book for the answers, if not a stick of candy.

1. Which Jack knew about proteins?
2. Which Jack knew about carbohydrates?
3. Which Jack knew about H_2O and acetic acid?
4. Which Jack knew about combustion?
5. What little girl knew about casein and lactic acid?
6. What calamity involved albumin and calcium carbonate?
7. Who captained the ship that was rigged with a precious metal and animal fiber?
8. Who grew a precious metal in her garden?
9. Who used another metal for ammunition?
10. What queen used a liquid balsam for cosmetic purposes?

Do They Mean It?

➤ When roots of words and chemical prefixes and suffixes get together, the result sometimes adds joy to the chemist's vocabulary. How many of these have you run across in your lab?

Example: If a certain metal were called by its common name, which of its oxides would be cruelly humorous? Ans.; Fe_2O_3, ironic oxide.

Unlike the example above, all the following questions are to be answered by the ordinary names of the compounds asked for.

1. Which acid must belong in the Table?
2. Which acid is colossal?
3. Which acid strives to improve the human race?
4. Which acid has heavenly associations?
5. Which mineral should you take to the dinner table?

Count 20 for each correct answer. If you score 60 you are a pretty good chemist, 80 you are as good as the acid in No. 2, 100 you are the answer to No. 4, or else you, too, have just read the dictionary.

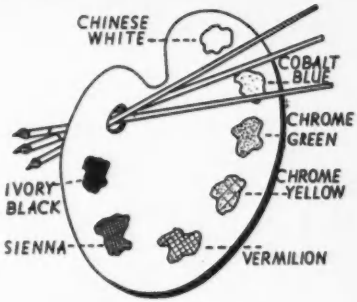
F	T	P	Y	R	M
V	A	L	O	B	E
D	M	C	A	R	P
E	I	U	I	O	C
L	S	D	T	N	Z
E	H	A	E	L	I

Chemical Word Square

➤ For a vacation amusement, see how many chemical terms you can find in this word square. Begin anywhere, move to the adjoining square, either straight or on the diagonal, use the same letter over again if you wish. You can see *zinc* quite clearly in the lower right-hand corner. A list of words that we found is given but we are sure you can do better.

The Painter's Palette

➤ THE PAINTER'S PALETTE holds many inorganic pigments. Can you give the formulas for those shown here? The answer page completes the picture.



Chemical Guessing Game

➤ A CHEMICAL variant of an old puzzle form uses the name or symbol of an element or a radical instead of a letter or syllable of a word. We explain one jingle and let you play with the others. The chemicals we had in mind will be found among the answers.

My first's a symbol which negates "yes,"
My second's vapor's a freshman's dress;
The two together add to the taste,
And keep your food from going to waste.

The symbol for sodium could be pronounced "nay," chlorine's vapor is (at least a little bit) green, the freshman's color. NaCl is a food preservative!

1. My first is in lime, but not in a drink;
My second's in soda—still not what what you think;
My whole in strata of rock is found,
And makes beautiful caverns under the ground.
2. My first is the lightest, and easily wed,
My second's a radical, not at all red;
Combined, they make a gas of death—
If near it, you must hold your breath.
3. My first's the name of a bonny lass,
My whole is poured in a brimming glass;
My second loudly you might shout
If you saw a guy pass out.
4. My first's in a pigment of yellow hue,
That we can't use now as we used to do;
My second makes sand fly away as gas,
And etches pictures in things of glass;
My whole is the answer to the hopes
Of the separators of isotopes.

Can You Neutralize Them?

➤ THESE PAIRS of acids and bases will react to form salts. After you have written the formulas for the equations turn to the answer section and give yourself 20 for each one you got right.

1. Caustic Potash + Prussic Acid
2. Baryta Water + Oil of Vitriol
3. Spirit of Hartshorn + Spirit of Nitre
4. Slaked Lime + Muriatic Acid
5. Magnesia Alba + Spirit of Salt

What Would Your Friends Say?

➤ WHAT would your friends say if they saw you wearing these chemicals in a ring or pin? The chemicals are all hard. See if they are hard to guess.

For example, if the set in your ring is *C*, your friends would say it is a diamond. Here are the formulas for ten more gems. All are common, though rare.

Count 10 for each one you identify correctly. Five of them are easy. For seven right you may consider yourself a jewel expert. If your score is 100, you are a (2.) of great price.

1. SiO_2
2. $CaCO_3$
3. Al_2O_3
4. $Be_3Al_2(SiO_3)_6$
5. $ZrSiO_4$
6. $(Al_3Mg_3Li_3)\ (BOH)\ (BF)SiO_{19}$
7. $(AlF)_2SiO_4$
8. $Al_2(OH)_3PO_4.H_2O$
9. $Na_4(NaS_3Al)Al_2(SiO_4)_3$
10. $MgAl_2O_4$

Clues to Chemical Crossword Puzzle

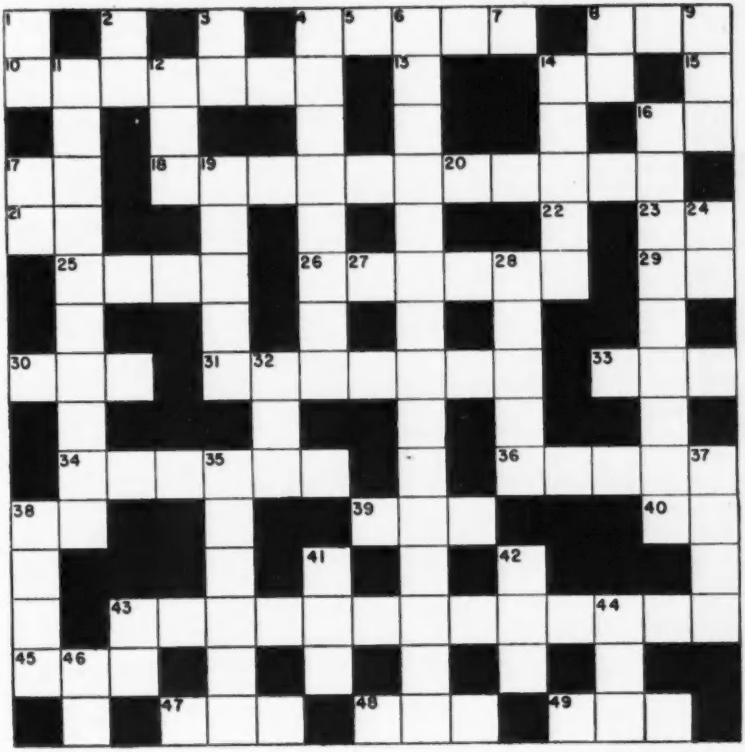
ACROSS

4. Combining form of a Group I metal
8. Prefix meaning three
10. Nitrogen compound
13. Hydrogen
14. Aluminum
15. Sulfur
16. Molybedenum
17. Cesium
18. Compound of carbon and nitrogen
21. Bismuth
22. Nitrogen
23. Radium
25. Famous balsam
26. Organic solvent
29. Volume measure
30. Prefix meaning sweet
31. Yellow element, old spelling
33. A source of salt
34. Inorganic acid
36. Kind of caustic
38. Iron
39. Sourse of organic compounds
40. Sodium
43. Hydroanisoins
45. Source of albumin
47. Water phase
48. Halogen suffix
49. Mode of analysis

DOWN

1. Protoactinium
2. Thulium
3. Tin
4. Organic radical
5. Uranium
6. Indicator
7. Oxygen
8. Thallium
9. Prefix meaning equal
11. Symmetrical trimethyl benzene
12. Suffix meaning of higher valence
14. Nitrogen and hydrogen
16. Smelly compound containing sulfur
17. Its other name is niobium
19. Certain crystalline sulfates
20. Iodine
24. Actinium
27. Yttrium
28. 3,7-dimethyl-2,6-octadien-1-ol
32. Prefix meaning one
35. Combining form of a rare metal
37. Laboratory animals
38. One form of energy
41. Charged atom
42. Types of dyes
43. Mercury
44. Of lower valence
46. Gallium

All-Chemical Crossword Puzzle



Clues for solving this puzzle are on the opposite page. The answer is on page 108.

Answers to Chem Quizzes

What's the Dope? p. 11

(1.) Ethyl alcohol
(2.) Morphine
(3.) Caffein
(4.) Cocaine
(5.) Aspirin
(6.) Heroin
(7.) Ephedrin
(8.) Adrenalin
(9.) Nicotine
(10.) Benzedrine
(11.) Phenobarbital
(12.) Codeine

It's the Law! p. 18

➤ 1. GAY-LUSSAC'S LAW: The volumes assumed by a given mass of a gas at different temperatures, the pressure remaining constant, are directly proportional to the corresponding absolute temperatures. (This is sometimes known as Charles' law, on authority of a quotation by Gay-Lussac.) Joseph Louis Gay-Lussac (1778-1850) was Professor of Chemistry at the Sorbonne, Paris.

2. BOYLE'S LAW: The volume occupied by a given mass of any gas at constant temperature varies inversely as the pressure to which it is subjected. Robert Boyle (1627-1691), son of the Earl of Cork, was one of the founders of the Royal Society.

3. AVOGADRO'S LAW: Under the same conditions of temperature and pressure, equal volumes of all gases contain the same number of molecules. The numerical value comes out at 6.06×10^{23} molecules per mole. Amedeo Avogadro (1776-1851), Conte di Quaregna, was Professor of Physics at Turin University.

4. DALTON'S LAW: The pressure exerted by each component in a gaseous mixture is independent of other gases in the mixture, and the total pressure of the mixture of gases is equal to the sum of the pressures of the separate components. John Dalton (1766-1844), who is credited with introducing the concept of the atom into modern chemistry, was a teacher at New College, Manchester, England.

5. FARADAY'S LAW: In the process of electrolytic changes equal quantities of electricity charge or discharge equivalent quantities of ions at each electrode. Michael Faraday (1791-1867), who gave us so many discoveries in electricity, was letturer at the Royal Institution, London.

6. GRAHAM'S LAW: The relative rates of diffusion of gases under the same conditions are inversely proportional to the square roots of the densities of those gases. Thomas Graham (1805-1869), Professor of Chemistry at University College, London, succeeded Sir John Herschel as Master of the Mint.

7. RAOULT'S LAW: Molar weights of non-volatile non-electrolytes dissolved in a definite weight of a given solvent under the same conditions lower the solvent's freezing point, elevate its boiling point and reduce its vapor pressure equally for all such solutes. Francois Marie Raoult (1830-1901) was Professor of Chemistry at Grenoble, France.

8. VAN'T HOFF'S LAW: If the temperature of interacting substances in equilibrium is raised, the equilibrium

concentrations of the reaction are changed so that the products of that reaction which absorbs heat are increased in quantity, or, if the temperature is lowered, products which evolve heat are increased. Jacobus Hendricus van't Hoff (1852-1911), Dutch chemist, was a Professor at the University of Berlin.

9. GIBBS' PHASE RULE: F stands for the number of degrees of freedom of temperature, pressure and concentration which fix the system. Josiah Williard Gibbs (1839-1903) was Professor of Physics at Yale.

On the Scent, p. 32

➤ ACETAMIDE CH_3CONH_2 smells like mice
amyl acetate $CH_3CO_2C_5H_{11}$ bananas
amyl valeriate $C_4H_9CO_2C_5H_{11}$ apples
benzaldehyde C_6H_7CHO almonds
ethyl butyrate $C_3H_7CO_2C_2H_5$ pineapples
ethyl formate $HCO_2C_2H_5$ peach kernels
ethyl sulfide $(C_2H_5)_2S$ garlic
methyl cinnamate $C_6H_5CH \cdot CHCO_2CH_3$ strawberries
methyl salicylate $OHC_6H_4CO_2CH_3$ wintergreen
phenyl acetaldehyde $C_6H_5CH_2CHO$ hyacinths.

Who, When and Where, p. 62

1. *t.* LEO HENDRIK BAEKELAND (1863-1944), Belgian-American, invented photographic printing paper sensitive to artificial light, and bakelite, one of the earliest synthetic plastics.

2. *m.* MARCELLIN PIERRE EUGENE BERTHELOT (1827-1907), French, studied the theory of organic compounds and of explosives, and the literature of the alchemists.

3. *i.* CLAUDE LOUIS BERTHOLLET (1748-1822), French, worked with Lavoisier on chemical nomenclature and structure of compounds and studied gunpowder and dyes.

4. *l.* JÖNS JAKOB BERZELIUS (1779-1848), Swedish, determined atomic weights and combining weights and was a pioneer in applying electricity to chemistry.

5. *g.* ROBERT BOYLE (1627-1691), English, was the author of the "Sceptical Chymist" and of Boyle's Law, and was one of the founders of the Royal Society.

6. *u.* WALLACE HUME CAROTHERS (1896-1937), American, played a leading part in the development of Neoprene and invented Nylon.

7. *k.* HUMPHRY DAVY (1778-1829), English, discovered "laughing gas," invented the miner's safety lamp and isolated a number of metals electrolytically.

8. *o.* JOSIAH WILLARD GIBBS (1839-1903), American, formulated the Phase Rule which reduces to calculation the conditions under which compounds form.

9. *f.* JOHANN RUDOLF GLAUBER, (1604-1668), German, prepared a

large number of acids, salts and other inorganic compounds new in his time.

10. *n.* Friedrich August Kekulé (1829-1896), German, introduced the theory of the ring formation in the structure of benzene, foundation of the aromatic series of compounds.

11. *q.* Henri Moissan (1852-1907), French, isolated fluorine, studied high-temperature reactions and believed he had made diamonds artificially.

12. *d.* Theophrastus Bombastus von Hohenheim, *alias* Paracelsus, (1490-1541), German, introduced chemical remedies and experimental techniques into medicine at an early date.

13. *h.* Joseph Priestley (1733-1804), English-American, prepared oxygen from mercuric oxide, naming it "dephlogisticated air," studied a variety of other gases, and emigrated to America because of religious and political difficulties at home.

14. *p.* Ira Remsen (1846-1927), American, taught, founded the American Chemical Journal, synthesized saccharin.

15. *c.* Abu Bakr Muhammad ibn Zakariya al-Razi, known as Rhazes in literature (9th c. A.D.), Persian, applied chemical knowledge to medicine and wrote in Arabic.

16. *s.* Edgar Fahs Smith (1856-1928), American, worked on atomic weight determinations but was especially interested in the history of chemistry in America.

17. *j.* Louis Jacques Thénard (1777-1857), French, advanced knowledge of the structure of many chemicals, in association with Gay-Lussac, and promoted the teaching of chemistry.

18. *a.* Theophrastus (372-287 B.C.), Greek, succeeded Aristotle as head of the Peripatetic School and wrote on plants, stones, physics, sensations and "ethical characters."

19. *e.* Jean Baptiste van Helmont (1577-1644), Belgian, was interested in fermentation, and coined the word "gas."

20. *r.* Jacobus Hendricus van't Hoff (1852-1911), Dutch, worked out the theory of stereo-isomerism of chemical molecules and developed the idea of the asymmetric carbon atom.

21. *b.* Zosimos of Panoplis (3rd or 4th c. A.D.), Egyptian, is the earliest writer on alchemy of whom we have the genuine writings.

Who Was the Man?

pp. 26, 32, 48, 62

A. Isaac Babbitt (1799-1862), English metallurgist, invented **Babbitt Metal**, for anti-friction bearings. It originally consisted of 24 parts tin, 8 parts antimony, 4 parts copper. In later compositions the proportion of tin is often considerably higher.

B. Johann Rudolf Glauber (1604-1668), German alchemist and nostrum seller, first described **Glauber's Salt**, $Na_2SO_4 \cdot 10H_2O$, and made extravagant claims for its curative properties. We are indebted to him for modern methods of preparing hydrochloric and nitric acids and many common inorganic salts.

C. Victor Grignard (1871-1935), French chemist, Professor of Chemistry at Nancy, was awarded the

Nobel Prize in 1912 for his discovery of the **Grignard Reaction** and preparation of organo-magnesium and similar compounds. His reagents facilitate the building up of complex organic compounds.

D. William Nicol (1768?-1851), Scotch physicist and mineralogist, invented the **Nicol Prism** and set two of them in a pair of tongs so arranged that they would allow light polarized by one prism to be analyzed by the other. Nicol was a skilled lapidary, and cut lenses for his microscope from garnets and other precious stones.

E. William Prout (1785-1850), English physician, worked in physiological chemistry and discovered that the gastric juice contains HCl. His name is linked with **Prout's Hypothesis**, originally published anonymously, suggesting that all chemical elements may be composed of hydrogen.

Old Salts, p. 84

1. Cupric sulfate, $CuSO_4 \cdot 5H_2O$ (*e*).
2. Mercurous chloride as medicine, HgCl (*a*).
3. Calcium hypochlorite, $Ca(ClO)_2 \cdot 4H_2O$ (*h*).
4. Ferrous sulfate, $FeSO_4 \cdot 7H_2O$ (*f*).
5. Potassium bitartrate used in cooking, $KHC_4H_4O_6$ (*l*).
6. Magnesium sulfate as medicine, $MgSO_4 \cdot 7H_2O$ (*x*).
7. Zinc oxide, ZnO (*c*).
8. Ferrous sulfate, $FeSO_4$ (*f*).
9. Sodium thiosulfate in photography, $Na_2S_2O_3 \cdot 5H_2O$ (*r*).
10. Yellow lead oxide, PbO (*t*).
11. Potassium sulfide, K_2S (*n*).
12. Silver nitrate, $AgNO_3$ (*w*).
13. Sodium ammonium phosphate, $NaNH_4HPO_4 \cdot 4H_2O$ (*q*).
14. Copper acetoarsenite as poison, $3CuOAs_2O_3 \cdot Cu(C_2H_3O_2)_2$ (*b*).
15. Nickname for the poison, arsenic trioxide, from the alleged custom of the crown prince administering it to the king. As_2O_3 (*g*).
16. Ferric ferrocyanide as a pigment, $Fe_4(Fe(CN)_6)_3$ (*v*).
17. Red lead oxide as a pigment, Pb_3O_4 (*u*).
18. Pharmacist's name for ammonium chloride, NH_4Cl (*k*).
19. Glauber's salt, sodium sulfate, $Na_2SO_4 \cdot 10H_2O$ (*o*).
20. Sodium carbonate, Na_2CO_3 (*p*).
21. Probably relating to the wisdom of the alchemists, though it may sound silly to us: ammoniomercury chloride, $HgNH_2Cl$ (*j*).
22. Potassium nitrate, KNO_3 (*m*).
23. Calcium hydroxide, $Ca(OH)_2$ (*i*).
24. Lead acetate, $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ (*s*).
25. Zinc sulfate, $ZnSO_4 \cdot 7H_2O$ (*d*).

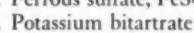
Can You Tell Them Apart? p. 87

Benzene—C_6H_6

Benzine—a light gasoline fraction.

Benzoin—$C_6H_5CHOHCOC_6H_5$

Fluorene—$C_6H_4CH_2C_6H_4$



Fluorine—one of the elements.

Hexane—$CH_3(CH_2)_4CH_3$

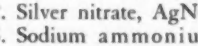
Hexene—$CH_2{:}CH(CH_2)_3CH_3$

Hexyne—$CH{:}C(CH_2)_3CH_3$

Ketene—$CH_2{:}CO$

Ketine—

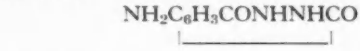
$N{:}C(CH_3)CH{:}NC(CH_3){:}CH$



Ketone—CH_3COCH_3
(dimethyl ketone, acetone)

Luminal—phenobarbital

Luminol—



Populin—$C_{20}H_{22}O_8$

Popular—what these quizzes will not be if we put in too many such puns.

Quiz Corner Answers

Among the Immortals

1—E. Mercury was wing-footed.
2—N. Vanadis was a goddess of beauty.
3—K. Thor threw his hammer around to make thunder.
4—C. Kobolds were demons who haunted mines, but never did any work.
5—H. The Palladium was a statue of the goddess Pallas. It was a meteorite.
6—L. The Titans were giants.
7—A. Cadmus sowed dragon's teeth, in Egypt, and raised an army.
8—G. Nickel is named for the Old Nick.
9—B. Cerium for Ceres, via the asteroid of the same name.
10—J. Tantalus never got a chance to take a drink, for he could not reach the water. The element is named from this circumstance.
11—D. Iris was the goddess of the rainbow, showing the end of the storm.
12—F. Neptune was the god of the sea.
13—M. Uranus was the ancester of all the gods.
14—I. Pluto was the god of the dead (and the atom bomb).

Colors of the Rainbow

a. Iridium, from Latin *Iris*, the Goddess of the Rainbow.
b. Iodine, from Greek *iodes*, violet.
c. Cesium, from Latin *caesius*, sky blue; Indium, from *indigo*.
d. Chlorine, from Greek *chloros*, green; Praseodymium from Greek *prasios*, green; Thallium, from Greek *thallos*, green twig.
e. Zirconium, from Arabic *zargun*, color of gold.
f. Rhodium, from Greek *rhodon*, rose; Rubidium, from Latin *rubidus*, red.

Geography of Elements

1. America—Am Cb; Cypress—Cu; Europe—Eu; France—Fa, Ga; Germany—Ge; Magnesia—Mg, Mn; Poland—Po; Scandinavia—Sc, Tm; Russia—Ru (Ruthenia is a form of the word *Russia*, so says *Enc. Brit.*); the Rhine—Re.

2. Copenhagen, Denmark—Hf; Stockholm, Sweden—Ho; Paris France—Lu; Strontia, Scotland—Sr. Ytterby, Sweden—Er, Tb, Yb, Y.

3. (*a*) Gd for Gadolin; (*b*) Sm for Samarski; (*c*) Cm for Pierre and Marie Curie.

The Et Ceteras

➤ SOME ELEMENTS got their names like this:

1. (*a*) $_{13}$Al from alum; (*b*) $_{4}$Be from the beryl; (*c*) $_{5}$B from borax; $_{9}$F from fluospar; (*d*) $_{14}$Si from silex; (*e*) $_{20}$Ca from calx, the heel bone.

2. $_{51}$Sb, in the book: *The Triumphal Car of Antimony*, by Basil Valentine.

3. (*a*) $_{82}$Pb and $_{42}$Mo both mean *lead*, (*b*) $_{47}$Ag and $_{78}$Pt both mean

silver, (*c*) $_{10}$Ne and $_{60}$Nd are both derived from *new*; (*d*) $_{43}$Te refers to the element's artificial production by *technical* methods. $_{85}$At refers to the element's unstable, or *a-static*, condition.

4. (*a*) $_{66}$Dy = hard to speak with; (*b*) $_{19}$K, Cinderella sat among the (pot)ashes; (*c*) $_{33}$As, the Arabic name sounded like the Greek *arsenikos* = male; (*d*) $_{54}$Xe = stranger.

5. (*a*) $_{52}$Te from tellus, earth; $_{2}$He from helios, sun; $_{34}$Se from selene, moon. (*b*) $_{80}$Hg, $_{92}$U, $_{93}$Np, $_{94}$Pu. (*c*) $_{58}$Ce,$_{46}$Pd. (*d*) $_{15}$P.

6. (*a*) $_{89}$Ac, $_{91}$Pa, $_{88}$Ra, $_{86}$Rn all refer to rays; (*b*) $_{56}$Ba, $_{74}$W both mean heavy; (*c*) $_{36}$Kr, $_{57}$La both mean hidden; (*d*) $_{35}$Br, $_{76}$Os both mean stinky.

7. 61 has been named *Illinium* by Dr. B. Smith Hopkins, who discovered its spectrum lines in a naturally-occurring mineral in 1926; it has been named *cyclonium* by Dr. M. L. Pool and L. L. Quill, who made it in the cyclotron at Ohio State University; and it has been named *Prome thium* (or *-eum*) by Drs. Marinsky, Glendenin and Coryell who isolated it from among the fission products of the atomic pile at Oak Ridge.

Do You Know the Atom?

➤ In the architecture of the atom we find *neutrons*, together with protons, in the nucleus, and *electrons* "revolving in orbits" around them. We find *positrons*, like electrons except for opposite electric charge, shooting out of artificially radio-active elements. Nuclear physicists postulate the neutrino, which has not been found, to account for slight inequalities between mass and energy. The mesotron is a particle heavier than an electron but lighter than a proton, which is found in cosmic rays. The rest of the *-trons* were just put in to make it harder. The *calutron* is a piece of apparatus contrived out of the *Cal*ifornia *U*niversity cyclo*tron* for the atomic bomb research. The *thyratron* is one kind of radio tube. *Natron* is an old name for sodium.

Atomic Power

➤ 1. False. Atomic energy power plants have to be shielded so heavily from radio-active fission products that they would be impractical for use in automobiles.

2. False. The so-called "secret" of the atomic bomb lies in tables of mathematical functions, reams of lab-

Number, Please?

1. Neon 10
2. Oxygen 8
3. Gadolinium 64
4. Lanthanum 57
5. Nitrogen 7
6. Calcium 20
7. Mercury 80
8. Beryllium 4
9. Sodium 11
10. Chlorine 17
11. Cadmium 48
12. Osmium 76
13. Thorium 90
14. ? 97
15. Helium 2
16. Aluminum 13
17. Fluorine 9
18. Lithium 3
19. Phosphorus
20. Indium 49

oratory reports and scientific experience capable of applying this data.

3. False. There are known large deposits of uranium in many parts of the world, and doubtless many still undiscovered.

4. False. Burning is oxidation, combining carbon and oxygen atoms. Fission going on in a chain-reacting pile changes the nucleus of the atom itself.

5. True. The process of thermal diffusion works on this principle.

6. True. Dr. Glenn T. Seaborg, one of the discoverers of plutonium has found minute amounts of it in an ore of uranium.

7. True. Plutonium is formed from uranium 238 by beta ray transformation, then it emits an alpha ray and changes into uranium 235.

8. False. The atomic bomb will not explode unless it has a mass larger than the critical mass. Atomic bombs will become larger rather than smaller.

9. False. There is no known protection against the atomic bomb.

10. True (probably, although we can't do it now). It may be possible to use atomic power plants for large ships, where the necessary shielding can be installed. A very small volume of fuel would be required, compared to present day fuel storage needs. What is meant by this frequently repeated statement is the total conversion of the mass of chemical elements into energy. In obtaining energy from present atomic fission only a very small fraction of the mass is so converted. If it ever becomes possible to convert the whole of the atoms of hydrogen and oxygen into energy, this statement would be true.

State of the Elements

➤ IF YOU ARE in too much of a state to locate the towns with the elemental names, here they are. The U. S. Postal Guide is our authority.

Antimony, Utah
Calcium, N. Y. and Pa.
Carbon, Pa.
Cobalt, Conn.
Krypton, Ky.
Lithium, Mo.
Mercury, Texas
Neon, Ky.
Platinum, Alaska
Radium, Colo., Kans. and Minn.
Vanadium, N. Mexico
Zinc, Ark.

How Long?

➤ IT IS LATER than you think, and some of the elements just getting famous have been around quite a while. Here is the correct list of dates announcing the discoveries of elements now in the news.

1735—Platinum
1755—Magnesium
1766—Hydrogen
1771—Fluorine
1774—Chlorine
1789—Uranium
1797—Chromium
1803—Cerium
1811—Iodine
1823—Silicon
1827—Aluminum
1828—Thorium
1828—Bromine
1868—Helium
1885—Praseodymium
1898—Radium
1898—Neon
1922—Hafnium
1942—Plutonium
1945—Curium

When Did We Find Them?

1. The metals known to the ancients were (1) gold, (2) silver, (3) copper, (4) tin, (5) iron, (6) lead, (7) mercury.

2. The following metals have been made by transmutation: 93—Neptunium, 94—Plutonium, 95—Americium, 96—Curium.

3. Arsenic was discovered during the Middle Ages.

4. Every member of the human race discovers oxygen and nitrogen with his first breath!

What For?

➤ Specific uses for the metals listed are: copper for electricity, magnesium for flashes, radium to treat cancer, strontium for red fireworks, mercury for thermometers, zinc to galvanize iron, iridium for fountain pen points, cerium for lighters, selenium for photo-electric cells, beryllium to emit neutrons when bombarded, plutonium for atomic bombs (better than uranium), chromium to make things shiny, gold for monetary standard (well, it used to be), tin cans for food, lead for storage batteries, arsenic for poisons for man or beast, insect or fungus (ask your farmer).

In Mother Goose

1. Jack Spratt got all the protein at his house.
2. Little Jack Horner stuck in his thumb and pulled out a (sugar) plum.
3. Jack and Jill got the water, and he mended his head with vinegar and brown paper.
4. Jack jumped over the candle stick.
5. Little Miss Muffet was eating her curds and whey.
6. Humpty Dumpty is universally reported to have been a good egg.
7. The captain was a duck, (remember?) of the ship whose sails were all of velvet and her masts of beaten gold.
8. Mistress Mary, quite contrary, grew silver bells with her cockle shells.
9. There was a little man, and he had a little gun, and his bullets were made of lead, lead, lead.
10. Queen, Queen Caroline
    Washed her hair in turpentine.

Do They Mean It?

1. $HIO_4 \cdot 2H_2O$, Periodic Acid.
2. H_2TiO_3, Titanic Acid.
3. $C_3H_5C_6H_3(OH)OCH_3$, Eugenic Acid.
4. $CH_2CHCH(CH_3)COOH$, Angelic Acid.
5. $Ca(CaF)(PO_4)_3$, Apatite.

Chemical Word Square

acid	calcium	lead
alloy	cobalt	ozone
amide	copper	palladium
barium	DDT	proton
beryl	helium	silica
boric acid	ion	tin
boron	iridium	TNT
cadmium	iron	zinc

The Painter's Palette

➤ Pigments on the palette are:

Chinese white—ZnO
Cobalt blue—CoO
Chrome green—Cr_2O_3
Chrome yellow—$PbCrO_4$
Vermillion—HgS
Sienna—$Fe_2O_3 \cdot MnO_2$
Ivory black—C

Chemical Guessing Game

1. First: Ca in CaO; second: CO_3 in Na_2CO_3; whole: $CaCO_3$.
2. First: hydrogen; second: cyanogen; whole: HCN.
3. First: ethyl; second: OH; whole: ethyl alcohol, C_2H_5OH.
4. First: uranium; second: fluorine; whole: UF_6.

Can You Neutralize Them?

1. $KOH + HCN \rightarrow H_2O + KCN$ Potassium cyanide.
2. $Ba(OH)_2 + H_2SO_4 \rightarrow H_2O +$ $BaSO_4$ Barium sulfate.
3. $NH_4OH + HNO_3 \rightarrow H_2O +$ NH_4NO_3 Ammonium nitrate.
4. $Ca(OH)_2 + 2HCl \rightarrow H_2O +$ $CaCl_2$ Calcium chloride.
5. $4MgCO_3 \cdot Mg(OH)_2 + 10HCl \rightarrow$ $6H_2O + 4CO_2 + 5MgCl_2$ Magnesium chloride.

What Would They Say?

➤ IF YOUR FRIENDS saw you wearing the chemicals whose formulas are listed as this Chem Quiz, they would call them by the names given here.

We do not guarantee that these are the only possible formulas, especially for the silicates. If your gems don't analyze out just this way, don't say we didn't warn you!

1. Opal, amethyst or quartz
2. Pearl
3. Ruby or sapphire
4. Beryl or emerald
5. Zircon
6. Tourmaline
7. Topaz
8. Turquoise
9. Lapis lazuli
10. Spinel

➤ DON'T look now, if you have not done it, but turn to page 99.

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